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THE RUSSIAN FUR-SEAL ISLANDS.

BY

LEONHARD STEJNEGER,

Of the United States National Museum.

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1.—THE RUSSIAN FUR-SEAL ISLANDS.

By LEONHARD STEJNEGER,
Of the United States National Museum.

I.—INTRODUCTION.

The following treatise is based upon observations gathered during two different visits to the Commander Islands, off the coast of Kamchatka, the first undertaken in 1882–83, during the palmiest days of the fur-seal industry, the latter being last year (1895), as a special attaché of the United States Fish Commission, to study the recent decline and to compare the conditions as I knew them thirteen years ago with those of the present day.

I undertook the trip with a full understanding of the difficulties awaiting me, both in the studies in the field and in the working up of the report. I was fully aware that, alone in an almost untrodden field, my work would of necessity be fragmentary and for that reason unsatisfactory. Nevertheless, I felt that I ought to do it for several reasons. In the first place I was in possession of a great amount of interesting information about the Russian seal islands never published, or else very inaccessible to those concerned in the fate of the fur-seal, which it might be useful to bring together. In the second place, I felt convinced that but few men were in the same fortunate position as myself of having had the opportunity to study the Russian fur-seal industry at close quarters while it was still flourishing, and that, consequently, I was in an exceptionally good position for instituting the desired comparison.

Finally, I reflected, having kept aloof from all the strife and controversy of recent years concerning seal matters, because I had no pet theories of my own to ventilate nor any personal interest of myself or friends to advance, I would be less liable to suspicion of being prejudiced or biased by any outside motive. I have earnestly endeavored to preserve this independence, personal and scientific, in the investigations which I have undertaken, and I claim that the conclusions I have reached are based upon the facts as I have been able to discern them. It is my hope that the logic of my deductions will not be found lacking.

SCOPE OF THE WORK.

At the suggestion of Mr. Richard Rathbun, in charge of the scientific inquiry of the Fish Commission, and with the approval of the Acting Commissioner of Fisheries, Mr. Herbert A. Gill, the scope of the report was extended so as to include all other obtainable information concerning the Russian seal islands, and it has thus assumed somewhat the character of a monograph. But I wish it distinctly understood that it does not pretend to exhaust the subject in any direction. Some of the chapters are

only brief résumés, thus causing great inequality in the treatment of the various questions. This could not well be otherwise, for it would have been manifestly impossible to prepare a work of that scope, with all the labor and research it involves, in the short time of 3½ months which I have had at my disposal for writing this treatise. Moreover, such an exhaustive work could not be done here in Washington or even in this country. It would have been necessary to consult records and archives in San Francisco and in St. Petersburg, as well as the libraries in the latter city.

In preparing this work I have had the hearty cooperation of the authorities of the United States Fish Commission, and I wish particularly to express my grateful appreciation of the truly scientific spirit and liberality shown by Mr. Rathbun in giving me every possible latitude for working out the problems in my own fashion without attempting to influence my opinion in any direction. His only injunction to me has been a desire for the facts as I have seen them. It has been my endeavor to supply them to the best of my ability.

ITINERARY.

My first visit to the Commander Islands was undertaken in March, 1882, under the joint auspices of the Smithsonian Institution and the United States Signal Service. With a notice of only two days, I left Washington on March 22, 1882, and sailed from San Francisco in the *Aleksander II* the following April 5, landing on Bering Island a month later—on May 7. During the summer I studied the fur-seals and rookeries on this island. In the fall of 1882 I undertook a circumnavigation of Bering Island in open boat, returning to the village after a successful trip of two weeks. The winter was passed on Bering Island, but part of the following summer, particularly the sealing season, I spent on the various rookeries of Copper Island. In October, 1883, I took passage in the *St. Paul* from Petropaulski, Kamchatka, to San Francisco, arriving in Washington the following November 26. The results of this trip have been published in numerous memoirs and papers, mostly issued by the United States National Museum.

The itinerary of my trip in 1895 is as follows: After receiving my appointment on May 21, I left Washington on May 28 with letters from the Russian legation, authorized telegraphically by the authorities in St. Petersburg, and arrived in San Francisco on Sunday, June 2. Various preparations for the journey occupied me until June 6, when I sailed in the steamship *Bertha* for Unalaska. In this port I was to join the Fish Commission steamer *Albatross*, which, it was calculated, would have returned to Unalaska from its first trip to the Pribylof Islands at the time I was due there. In such an event Captain Drake had orders to bring me to Bering Island via the Pribylofs, in order to afford me an opportunity to witness and compare the mode of driving the seals on both groups. Upon my arrival at Unalaska on June 17 I found, however, that the *Albatross* had only arrived there the day before, without having as yet been to the Pribylofs. The following week was consumed in Unalaska taking in coal. The *Albatross* left Unalaska on June 23, and on June 25 we were landed at the village, St. Paul Island. The rookeries near the village were inspected the same afternoon.

Thanks to the zeal and courtesy of the Treasury agent, Mr. J. B. Crowley, and the company's general agent, Mr. J. Stanley-Brown, a small drive of seals was at once arranged for the following morning. Mr. F. W. True, of the United States National

Museum, and I partook in the drive, which lasted from 2 o'clock in the morning to 10 a. m. At 1 p. m. I embarked again on the *Albatross* and steamed at once away for Bering Island; anchored off the main village on July 3, and on the 4th, with Captain Drake and Mr. C. H. Townsend, went per dog-sledge to the great North Rookery. After having landed my effects, the *Albatross* left on the following day.

My next trip to the North Rookery was per boat, in company with Governor Grebnitski, on July 7. On July 15 I again proceeded to the same rookery in dog-sledge, returning to the main village by the same means July 20. Bad weather prevented the carrying out of my intentions of visiting the South Rookery at this time. On July 27 I took passage on the Russian Seal Skin Company's steamer *Kotik*, Capt. C. E. Lindquist, for Copper Island, and on July 30, in company with the governor, Mr. Grebnitski, who bore the expense of the trip, started from the main village on an open-boat expedition around the island. Spent the evening and the next morning at the sea-otter rookery. July 31 and August 1 were devoted to inspecting and photographing the Karabelni rookeries and August 2 to 11 to the Glinka rookeries, the latter being the more important ones, finishing the circumnavigation August 12. On the steamer *Kotik* I then returned to Bering Island, anchoring off the North Rookery August 13. Visited the South Rookery August 17, securing photographs and a map of the rookery. On August 18 I called on board the British cruiser of the third class *Porpoise*, Commander Francis R. Pelly (doing patrol service on the 30-mile limit), then at anchor off Nikolski. On August 21 I went in dog-sledge to the North Rookery, returning two days later. The captain of the *Porpoise* having kindly offered to take me to Petropaulski, I gladly accepted his offer, as it was somewhat doubtful whether the *Kotik*, in which I intended to return to San Francisco, would be able to call at the islands before going home, and I did not dare to risk the possibility of wintering on Bering Island. I arrived in Petropaulski August 25. The company's agent having decided to make another trip to the islands, I returned in the *Kotik* and was thus enabled to again inspect the Bering Island South Rookery on September 9 and the North Rookery September 16, being back in Petropaulski September 18, which port I left on September 24 in the *Kotik*, bound for San Francisco, where I arrived on October 11.

The weather was unprecedentedly stormy and rainy during my entire stay at the islands and interfered greatly with my work. The great distances between the habitations and the rookeries and the primitive means of transportation also added to the difficulties, while much valuable time was lost owing to the uncertainty of the movements of the steamer.

Under such adverse circumstances I should have been unable to accomplish even what I did had it not been for the kind assistance I received on all sides.

ACKNOWLEDGMENTS.

In the first place, it gives me great pleasure to acknowledge the aid and courtesies received at the hands of Governor N. Grebnitski, the administrator of the islands, without which I should have been seriously embarrassed in my work. The following report would undoubtedly have been more replete with official data and statistics relating to the sealing industry on the islands had not the documents relating thereto been either sent away already or packed ready for shipment in anticipation of Mr. Grebnitski's prospective departure for St. Petersburg.

I am also under great obligations to the firm and officers of the Russian Seal Skin Company, the present lessees of the islands, especially Mr. C. A. Williams, New London, Conn., and Mr. Thomas F. Morgan, Groton, Conn., as well as Mr. Constantine M. Grunwaldt, of St. Petersburg, at present the representative of the firm on the Pacific Coast; Mr. John Malovanski, of San Francisco, the general agent of the company; Capt. C. E. Lindquist, of the *Kotik;* Capt. D. Grœnberg, of the *Bobrik;* Mr. Kluge, the resident agent on Bering Island, and Mr. Cantor, on Copper Island.

It would be ungrateful not to mention the hospitality received from the Alaska Commercial Company and its functionaries, especially during my first visit to the islands. The liberality with which the members of this firm have been ever ready to assist scientific endeavors has contributed greatly to the success of my undertakings.

To Lieut. Commander F. J. Drake, U. S. N., commanding the United States Fish Commission steamer *Albatross,* and his officers, and to the scientific staff of the vessel, and more particularly to Mr. C. H. Townsend, special thanks are due for courtesies during my stay on board, and to the latter for valuable information received during the preparation of this report, due credit for which is given in each instance.

It is with great pleasure that I acknowledge my obligations to the captain of H. M. S. *Porpoise,* Commander Francis R. Pelly, R. N., and his officers, for hospitalities and for aid in transportation.

Finally, I wish to express my appreciation of the willingness and promptness with which my desire to witness a seal-drive on St. Paul Island was gratified by the Treasury agent, Mr. J. B. Crowley, and by Mr. J. Stanley-Brown, the general agent of the North American Commercial Company, the present lessees of the Pribylof Islands.

II.—THE RUSSIAN SEAL ISLANDS.

Until the purchase of the Territory of Alaska by the United States, in 1867, all the resorts of the northern fur-seal north of California belonged to the Russian Empire, and the fur-seal industry of the North Pacific was entirely monopolized by the Russian American Company.

These resorts were in all instances uninhabited islands, and at the time of their discovery by the Russian fur-hunters, in the middle and latter part of the last century, even unknown to the native races. The seals when first found on the rookeries, about one hundred and fifty years ago, had never been interfered with by man while on their breeding-grounds. The islands alluded to were the Commander group, certain small islands in the Okhotsk Sea, certain small islands in the Kuril chain, and the Pribylof group.

In 1867 the Pribylof Islands were sold to the United States, and in 1870 Russia ceded the Kurils to Japan in exchange for the southern half of the island of Sakhalin. There remain thus, in the possession of the Russian Crown at the present date, only the Commander Islands and the islands in the Okhotsk Sea.

1.—THE COMMANDER ISLANDS.

The Commander Islands (also occasionally called the Commodore Islands; Russian, *Komandorski Ostrova*), so named in memory of the great commander, Bering, who discovered the group, comprise two main islands, Bering and Copper, situated off the east coast of Kamchatka, between 54° 33′ and 55° 22′ north latitude, and 165° 40′ and 168° 9′ east longitude, approximately 97 miles from Cape Kamchatka, the nearest point on the mainland. The southeast point of Copper Island is distant from Attu, the nearest American island, about 180 miles, and is less than 75 miles from the imaginary boundary line across Bering Sea between Russia and the United States. The distance between Bering Island and the port of Petropaulski is somewhat more than 280 miles, while a straight line between the nearest points of the Commander group and the Pribylof group is 750 miles. The steamer's track between the former and San Francisco is something like 3,100 miles.

Geographically the Commander Islands are the westernmost group of the Aleutian chain. Politically, however, they form a separate administrative district of the so-called Coast Province (*Primorskaya Oblast*). This enormous territory extends from Korea to the Arctic Ocean, and, including the peninsula of Kamchatka, is ruled by the governor-general of the Amur Province, residing at Khabarovka, on the Amur River, more than 1,200 miles, as the crow flies, from the Commander Islands. The administrative position of these islands, however, is somewhat complicated, inasmuch as they also depend directly under the Minister of the Imperial Domain in St. Petersburg, 4,600 miles away. In other words, their position corresponds very much to that of our Pribylof Islands, which are subject both to the governor of Alaska and to the Secretary of the Treasury.

The Commander Islands were discovered on November 4, 1741 (old style). On that day the vessel *St. Peter*, with the commander, Vitus Bering, and nearly the entire

crew, sick to death with the scurvy, slowly approached the southern extremity of Copper Island from the east, on their return voyage, after having discovered the mainland of America. Owing to the universal sickness, the ship's reckoning was entirely out, and the officers believed themselves off the coast of Kamchatka. The next day the vessel, over which the exhausted crew had hardly any control, drifted toward the east shore of Bering Island, and in the night following, a beautiful, still November night, of which this coast knows but few, the unfortunate craft came pretty near being left by the receding tide and wrecked on the projecting reefs at the southern entrance to the little bay called Komandor on the map (plate 4). By an exceptional piece of good luck, the breakers carried it safely over the rocks into the basin beyond, and a landing was effected.

To such extremity were the discoverers reduced that it was decided to winter on this inhospitable shore. Hollows were dug in the ground for shelter and covered with skins of wild animals and sails. Many of the crew died of the scurvy, and on the 8th of December (old style) Bering himself. He was buried near the place marked on the map "Bering's grave." The others, 46 only out of 77, recovered slowly under the care of G. W. Steller, who accompanied the expedition as a naturalist. The vessel was thrown up on the beach during a heavy gale in the night between November 28 and 29 (old style), and all attempts to float it were in vain. The next spring, after a winter full of suffering and privations, the crew broke up the old vessel and of the materials built a smaller one, in which they landed at Petropaulski, Kamchatka, August 27, 1742.

The present writer visited the place of the shipwreck and the wintering August 30, 1882, and has given an account of it, with a ground-plan of the hut and a sketch map of the locality, in Deutsche Geogr. Blätter, 1885, pp. 265–266. A partial rendering of this is found in Prof. Julius Olsen's translation of Lauridsen's "Vitus Bering" (Chicago, S. C. Griggs & Co., 1889), p. 184, and additional notes, pp. 214, 215. The relics of the expedition found by me are deposited in the United States National Museum.

HYDROGRAPHIC NOTES.

It is astonishing how very little is definitely known about the hydrography of the western side of Bering Sea. But few vessels fitted for such work have visited that part of the world of late years, and those few have only made hurried passages through. In that way a small amount of material has been accumulated, which has been utilized by the Russian admiral, S. O. Makarof, in his interesting work "Vitiaz i Tikhi Okean" (2 volumes, St. Petersburg, 1894), in which, so far as the investigations relating to temperature and specific gravity of the waters of the western Bering Sea are concerned, his own observations on board the corvette *Vitiaz* form the most valuable part. This being the case, I have no hesitation in presenting, in a brief abstract, the substance of those paragraphs in his book which refer to the matter in hand, especially since a full understanding of the phenomena in question is a necessary basis for an equally full understanding of the distribution of the food animals of the seals and of the seals themselves.

On July 29, 1888, the *Vitiaz* left Petropaulski on a short trip to the Commander Islands. The bathymetric observations in Bering Sea have shown that the bed of warm water of a temperature of + 9° C. is very thin near the coasts of Kamchatka. At a depth of 10 meters a temperature of + 2. 3° C. is found and at 25 meters only

$+0.6°$. Near the Commander Islands, with the same surface temperature of $+9°$ C., $+7.1°$ was found at 25 meters and $+4.3°$ at 50 meters. We have here absolutely the same phenomenon as in the Japan Sea, viz, that the cold water predominates in the lower beds of the western portion of the sea. The identical phenomenon has been observed in the Okhotsk Sea and the Straits of Tartary.

The bathymetric observations in Bering Sea, at stations Nos. 108, 109, 110, and 113, have established another peculiarity of this sea, viz, the presence in the deeper portions of warm water of high salinity. Near the coast of Kamchatka the increase in temperature is shown as follows: At station No. 108, from 0° C. at 200 meters to $+3.5°$ C. at 400 meters; at station 109, from $+0.6°$ C. at 150 meters to $+2.6°$ C. at 175 meters and $+3.7°$ C. at 200 meters; at station 110, in longitude 165° 56′ E., at a depth of 100 meters a temperature of $+2°$ C. was found, and at 150 meters and below, $+3.9°$ C. The details are shown in the accompanying diagram (pl. 3).

These temperatures prove to us that the bed of warm water of great specific gravity is found nearer the surface at the Commander Islands than along the coast of Kamchatka. A similar phenomenon has also been observed in the Okhotsk Sea. In other words, the cold and less saline water in descending from north to south approaches the coast toward the western side of the sea and forces the warm water of high salinity to a greater depth.

Plate 3 shows a section of Bering Sea from the coasts of Kamchatka to the Commander Islands. The cold water here occupies an intermediate bed between the surface and a depth of 250 meters. As in the Okhotsk Sea, the bed thickens toward the mainland coast and tapers off as it recedes from it. It will also be seen that this cold water, with a temperature lower than 0° C., has a specific gravity of 1.0252 to 1.0254. Where does this water come from? Makarof concludes that as it can not come from the Pacific Ocean, which has no such temperature, it must descend from the surface. Since the surface water has a specific gravity of only about 1.0250, he suggests that the great salinity of this surface water is due to freezing in winter. As to the route this water follows, he believes that, as indicated by the temperatures observed by the *Tuscarora*, it advances from the southwest along the coast of Kamchatka and consequently also along the Kuril Islands.

The surface temperatures of the western portion of Bering Sea are indicated on pl. 2, showing the existence of two cold zones, viz, one near Capes Tchaplin and Tchukotski, the other between Capes Navarin and St. Thaddæus. Everywhere else the cold water occupies the western part of Bering Sea and the warm water its eastern portion. In the other places the distribution of the temperature is pretty regular; it decreases gradually toward the north. The temperature near Petropaulski is 11° C., and near the island of St. Lawrence about 8° C., i. e., the mean temperature of August.

Fragmentary as is our knowledge of the waters themselves in the western portion of Bering Sea, the bottom of the sea over which they flow is hardly better known. In fact, until the U. S. Fish Commission steamer *Albatross* ran the three lines of deep-sea soundings in 1892 and 1895, the shape and nature of the bottom were even less known. Even to-day we do not know the depth of the passage between Kamchatka and the Commander Islands. The Russian and English men-of-war patrolling the seas around the islands have of late years added a number of soundings at 100 fathoms and under, so that it has been possible on the appended map (pl. 1) to trace the 100-fathom line

with some degree of accuracy, but not even Makarof in the *Vitiaz* seems to have been provided with an apparatus fit to take soundings deeper than 400 fathoms. The soundings which he made in the passage alluded to, therefore, only prove that it is deeper than 400 fathoms, but how much we are unable to say. True, we find on the Russian Hydrographic Department chart No. 1454 (Vost. Okean, Bering. Mor.) two definite soundings, viz, 390 fathoms in 53° 41′ north latitude and 163° 29′ east longitude, but this being station No. 109 of the *Vitiaz*, and therefore in all probability taken from its records, we find upon turning to the latter that bottom was not found at 713 meters, or 390 fathoms. The other sounding on the same chart is 400 fathoms in 54° 45′ north latitude and 162° 50′ east longitude. By examining the records of the *Vitiaz* we find no soundings taken by that vessel in that latitude, but we find on the other hand that station No. 113 was in 53° 45′ north latitude and 162° 50′ east longitude, and that a sounding was there taken with the result that bottom was not touched in 732 meters, or 400 fathoms. The above figures are too close not to make it almost absolutely certain that by a clerical error the sounding in question was plotted a whole degree too far north and the dash with the dot over left out.

In the chart of the western portion of Bering Sea which I have prepared and appended herewith (pl. 1), the 100-fathom curve around the Commander Islands is drawn for the first time with some pretensions to accuracy. Even in some recent publications it is asserted that the Commander Islands "belong to the Kamchatka system, Copper Island resting just within the 100-fathom curve from the Asiatic coast." On the contrary, we know now that the sea between the mainland and the islands is over 400 fathoms deep. On my map they are connected with the peninsula of Kamchatka by the 500-fathom curve, but even that is only conjectural, though probable. The deep-sea soundings of the *Albatross* are here first shown on any map of the region, as well as the curves connecting them with the *Tuscarora* soundings of 1874. It will thus be seen that nearly all our knowledge of the bottom in this part of the sea is due to ships belonging to the United States.[1]

The curves of the various depths from 100 fathoms down to 2,000 fathoms and over are, as a matter of necessity, highly conjectural. In the northeastern section of the map they appear even somewhat problematical, in view of the fact that a series of shallow soundings running southwest from Cape Oliutorski, on the charts of the United States Hydrographic Office, have been left out of consideration altogether. The reason is that the series is crossed by the deep soundings of the *Albatross* on her return passage from the Commander Islands in 1895 in such a manner that it is impossible to reconcile them. They may possibly belong farther west—a not unreasonable supposition, since the determination of the longitude of the various coasts and promontories in that part of the world is in such utter confusion[2] that a resurvey of the whole coast from Petropaulski to Providence, or Plover, Bay is imperatively demanded.

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[1] I find on Berghaus's "Chart of the World on Mercator's Projection" a sounding of 2,700 fathoms indicated in (approx.) latitude 56° 40′ north and longitude 168° 20′ east, the authority for which I am ignorant of. It is situated almost in a line between the 1895 *Albatross* soundings of 2,137 and 1,866 fathoms, and if correct would indicate a depression below the general level of about 2,100 fathoms in that part of Bering Sea.

[2] Witness the fact that the various charts of the region for more than ten years have borne the following inscription: "The coast of Kamchatka north of Cape Koslof is reported to be charted 15 miles too far east." Yet nothing has been done to clear up the doubt.

Nevertheless, in all this uncertainty, the following points may now be regarded as fairly well established:

(1) The Commander Islands are situated on the extreme eastern point of a plateau-like ridge having a probable average depth of about 500 fathoms and extending eastward from the coast of Kamchatka.

(2) This plateau, upon which the Commander Islands are located, rises very abruptly from an ocean floor of a little more than 2,000 fathoms, so that the islands themselves on their northern and eastern sides rise nearly perpendicular out of this depth.

(3) Between the Commander Islands and Attu, the nearest of the American Aleutian Islands, there is a gap certainly more than 1,900 fathoms deep. Whether the *Albatross* maximum sounding of 1,996 fathoms, only a short distance from the south end of Copper Island, is really the maximum depth, thus indicating a slightly elevated ridge between the floor of the Bering Sea and the so-called *Tuscarora* deep, or whether there may not be a channel of 2,100 fathoms, or thereabouts, on one side of the sounding in question, remains to be seen.

(4) The bottom of Bering Sea to the east of the Commander Islands forms a nearly level floor of an almost uniform depth of 2,100 fathoms, sending off an arm, or bay, of equal depth to the north of the islands toward the neck of the Kamchatkan peninsula. The walls of this basin are excessively steep at the islands, but are believed to slope off gradually toward the curve of the coast between Capes Oserni and Oliutorski.

To complete the account I append the records of the soundings taken by the *Albatross* and the *Vitiaz* in the waters covered by the map (plate 1).

Records of recent soundings in the western portion of Bering Sea.

Hydro. station.	Date.	Time.	N. lat.	E. long.	Depth.	Bottom.	Vessel.
	1888.		° ′ ″	° ′ ″	*Fth'ms.*		
107	July 29	4 p. m.	52 58 0	160 02 0	49		Vitiaz.
108	July 29	6.40 p. m.	53 02 0	160 16 0	438		Do.
109	July 30	9 a. m.	53 41 0	163 29 0	390		Do.
110	July 30	8.15 p. m.	54 15 0	165 56 0	300		Do.
111	July 31	8.37 p. m.	54 39 0	166 35 0	55		Do.
112	Aug. 1	2.30 p. m.	55 02 0	165 15 0	109		Do.
113	Aug. 2	4.30 a. m.	53 45 0	162 50 0	400		Do.
	Aug. 2	4 p. m.	52 55 0	160 14 0	175		Do.
	1892.						
3231	May 29	10.40 p. m.	53 13 0	172 38 0	1,447	yl. M. fne. S.	Albatross.
3232	May 30	5.43 a. m.	53 38 0	171 28 0	1,818		Do.
3233	May 30	11.35 a. m.	54 02 0	170 17 0	1,853	fne. bk. S.	Do.
3234	May 30	6.12 p. m.	54 19 0	169 03 0	1,996	yl. M. S.	Do.
3235	May 31	12.03 a. m.	54 30 0	168 07 0	47	fne. gy. S.	Do.
3236	May 31	1.34 p. m.	55 09 0	165 51 0	25	rky	Do.
3237	May 31	3.10 p. m.	55 10 0	165 47 0	33	rky. M.	Do.
3238	May 31	4.33 p. m.	55 08 0	165 48 0	36	gy. S.	Do.
3239	May 31	5.34 p. m.	55 10 30	165 45 0	32	do	Do.
	1895.						
3546	June 30	3.04 p. m	55 59 0	178 43 0	2,105	br. M. oz	Do.
3547	June 30	10.25 p. m	55 55 0	177 12 0	2,113	do	Do.
3548	July 1	7.05 a. m	55 52 0	175 25 0	2,120	do	Do.
3549	July 1	4.35 p. m	55 53 0	173 53 0	2,111	do	Do.
3550	July 2	2.37 a. m	55 59 0	171 57 0	2,086	do	Do.
3551	July 2	10.20 a. m	56 00 0	169 46 0	2,154	do	Do.
3552	July 2	4.58 p. m	56 00 0	168 16 0	2,153	do	Do.
3553	July 2	11.07 p. m	55 58 0	166 43 0	2,119	gy. S. M	Do.
3554	July 3	2.21 a. m	55 43 0	166 15 0	2,090	do	Do.

Records of recent soundings in the western portion of Bering Sea—Continued.

Hydro. station.	Date.	Time.	N. lat.	E. long.	Depth.	Bottom.	Vessel.
	1895.		° ′ ″	° ′ ″	*Fth'ms.*		
3555	July 3	5.14 a. m	55 25 0	165 46 0	70	gy. S. M	Albatross.
3556	July 3	6.34 a. m	55 16 0	165 32 30	20	crs. S. rky	Do.
3557	July 3	7.10 a. m	55 12 0	165 38 0	35	gy. S	Do.
3558	July 3	7.31 a. m	55 11 0	165 40 0	37	do	Do.
3559	July 3	8.04 a. m	55 11 20	165 46 20	15	rky	Do.
3560	July 5	12.22 p. m	55 25 30	165 48 0	144	fne. gy. S	Do.
3561	July 5	12.49 p. m	55 27 0	165 49 0	66	rky	Do.
3562	July 5	1.17 p. m	55 28 30	165 51 30	341	gy. S. M	Do.
3563	July 5	2.20 p. m	55 32 0	165 56 30	1,087	S	Do.
3564	July 6	1.17 a. m	56 25 0	167 52 0	2,137	gr. oz	Do.
3565	July 6	7.15 a. m	56 56 0	169 06 0	1,866	bl. M. oz	Do.
3566	July 6	12.01 p. m	57 16 0	169 41 0	972	do	Do.
3567	July 6	2.29 p. m	57 29 0	170 09 0	410	gy. S. M	Do.
3568	July 6	4.15 p. m	57 35 0	170 24 0	537	br. oz. G	Do.
3569	July 6	6 p. m	57 41 0	170 39 0	609	br. oz. S	Do.
3570	July 6	7.22 p. m	57 47 0	170 54 0	540	gn. oz. G	Do.
3571	July 6	8.44 p. m	57 53 0	171 09 0	696	gn. M. oz	Do.
3572	July 11	12.37 a. m	58 13 0	171 51 0	1,469	do	Do.
3573	July 11	5.05 a. m	58 36 0	172 47 0	1,898	hard	Do.
3574	July 11	10.55 a. m	58 23 0	174 17 0	1,978	bl. M. oz	Do.
3575	July 11	5.04 p. m	58 12 0	175 49 0	2,041	br. M. oz	Do.
3576	July 11	11.07 p. m	58 01 0	177 21 0	2,068	do	Do.

METEOROLOGY.

The climate of the Commander Islands, in spite of their vicinity to Kamchatka, is not particularly severe, but the excessive moisture and the low summer temperature make it rather disagreeable, though by no means unhealthy. The chief interest centers in the temperature, the moisture, precipitation, and cloudiness for the months of May to November, inclusive, during which time the fur-seals stay on the islands. But as the meteorological observations made on the islands have never been published in full, or collectively, I have appended a set of tables of the monthly means for the four years during which the United States Signal Service maintained a station at Nikolski, Bering Island.

One of the objects of my trip to the Commander Islands, in 1882, was to establish meteorological stations there and in Petropaulski. The village at Copper Island was found unsuitable for the purpose and no regular observations were taken there. At Nikolski, however, I established and maintained during my entire stay a three-daily station, beginning May 22, 1882. During my sojourn there I trained the late Mr. George Chernick, agent of Hutchinson, Kohl, Philippeus & Co., in the use of the instruments, so that whenever I was absent from the station exploring, collecting, or investigating the rookeries, he took the observations. At my departure he was appointed a United States Signal Service observer, whose duties he conscientiously fulfilled until his resignation in April, 1886, at which time the station was abandoned.

The observations were taken simultaneously with those in Washington, D. C., viz, at 7 a. m., 3 p. m., and 11 p. m., Washington time, or, respectively, 11.12 p. m., 7.12 a. m., and 3.12 p. m., local time.

The instruments used were as follows:

A mercurial barometer, United States Signal Service, No. 1837.

An exposed thermometer, No. 939.

A minimum thermometer, No. 648.

A maximum thermometer, after June, 1883.

A wet-bulb thermometer, for determining the relative humidity, after June, 1883.

A Robinson's anemometer.

A wind vane, belonging on the island.

A Signal Service standard rain-gauge.

The barometer eistern was 20 feet above sea level.

The thermometers were hung in a large lattiee box on the north side of my house, the box eovering the window; and the instruments were read through the latter from the inside.

The rain-gauge[1] had to be loeated very high (9 feet) and in an exposed place to keep it from the marauding sledge-dogs. This instrument was not satisfactory in a high wind. The wind in blowing aeross the mouth of the funnel would aetually suek the air out of the latter, thus preventing the rain or snow from entering. Many a time after a considerable rain I have found the rain-gauge dry inside. The aetual amount of precipitation is therefore greater than shown in the table given below, though the figures in the latter may serve for eomparison with those from similar loealities in the United States, particularly on the Pribylof Islands and in Alaska, where the same kind of rain-gauge was in use.

The following tables I have transcribed direetly from the original reeords. The monthly means are those of the means of the three daily observations. The method of observing, correcting, and tabulating is that in vogue in the Signal Serviee, and the figures are strietly comparable with those of the other stations of the same Serviee.

Monthly means of Meteorologic Observations made by Leonhard Stejneger and George Chernick at Nikolski, Bering Island, from May, 1882, to April, 1886, inclusive.

MEAN MONTHLY BAROMETER.

[Corrected for temperature and instrumental error only. Elevation of barometer, 20 feet above sea level. Centr. gravity, + 0.030.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1882....	....	....	....	....	*29.805	29.738	29.720	29.827	29.842	29.807	29.660	29.524
1883....	29.392	30.053	29.784	29.846	29.783	29.752	29.837	29.816	29.775	29.603	29.817	29.512
1884....	29.565	29.540	29.579	29.744	29.811	29.938	29.721	29.785	29.947	29.747	29.355	29.560
1885....	29.397	29.848	29.905	29.730	29.705	29.693	29.840	29.766	29.882	29.765	29.750	29.612
1886....	29.517	29.794	29.781	29.600	....	....	....	....	....	....	....	....

* Means of 10 observations.

MEAN TEMPERATURE.

[The mean temperature was obtained by adding together the observations made at 7.12 a. m., 3.12 p. m., and 11.12 p. m., local time, and dividing by 3.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
1882....	....	....	....	....	* 39.7	42.7	48.2	54.1	50.5	38.8	28.7	27.0
1883....	25.5	28.7	25.2	28.6	35.3	41.7	45.9	51.9	45.2	38.0	31.4	28.8
1884....	25.9	28.9	28.3	30.7	36.6	42.2	48.1	49.5	45.9	37.4	31.1	26.4
1885....	26.9	25.7	27.4	27.7	35.1	41.9	46.2	48.3	45.6	34.8	29.9	26.9
1886....	27.4	27.0	27.2	30.7	....	....	....	....	....	....	....	....
Means.	26.4	27.6	27.0	29.4	35.7	42.1	47.1	51.0	46.8	37.2	30.3	27.3

Annual means: 1883, 35.5; 1884, 35.9; 1885, 34.7.
*Mean of 10 observations, May 22 to 31, not included in the means.

[1] Report Chief Sig. Off. 1887, II, p. 382, pl. XXXVI, fig. 97.

Monthly means of Meteorologic Observations at Bering Island—Continued.

MAXIMUM TEMPERATURE.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
1882....	....	....	....	....	....	....	....	....	....	*48.0	*40.3	*39.1
1883....	*33.0	*38.0	*33.9	*38.0	*56.0	59.5	57.5	63.0	57.0	49.1	42.9	40.7
1884....	36.6	36.8	38.9	39.5	45.4	53.5	62.7	55.7	56.0	49.9	38.2	37.0
1885....	36.1	43.4	36.0	39.8	48.5	56.6	62.9	57.1	53.6	51.0	44.0	38.0
1886....	37.0	38.0	37.0	39.0	....	....	....	....	....	....	....	....

Highest: 1883, August 23d, 63.0; 1884, July 19th, 62.7; 1885, July 24th, 62.9.
* Highest exposed.

MEAN MAXIMUM TEMPERATURE.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
1882....	....	....	....	....	....	....	....	....	....	....	....	....
1883....	....	....	....	....	....	*46.1	51.0	56.9	49.6	43.1	35.8	33.1
1884....	29.8	32.4	32.6	35.3	41.5	47.3	52.8	53.5	51.0	41.6	34.8	30.3
1885....	30.8	30.7	30.7	31.5	39.1	46.8	51.6	52.4	49.4	39.2	34.4	30.5
1886....	30.7	30.2	31.3	35.1	....	....	....	....	....	....	....	....

* Mean of 28 observations.

NUMBER OF DAYS OF MAXIMUM THERMOMETER BELOW 32°.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1882....												
1883....	....	....	....	....	....	0	0	0	0	0	8	12
1884....	17	11	14	4	0	0	0	0	0	0	4	17
1885....	17	15	18	16	1	0	0	0	0	0	10	20
1886....	17	17	13	5	....	....	....	....	....	....	....	....
Means.	17.0	14.3	15.0	8.3	0.5	0.0	0.0	0.0	0.0	0.0	7.3	16.3

Total: 1884, 67 days; 1885, 97 days.

MINIMUM TEMPERATURE.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
1882....	....	....	....	....	....	31.3	39.4	44.6	35.3	17.6	9.8	−1.4
1883....	3.3	10.8	11.2	5.3	25.8	33.4	34.6	39.5	31.3	24.5	15.5	9.8
1884....	6.3	9.5	12.2	0.6	27.4	31.5	37.3	38.2	30.4	22.4	13.4	6.2
1885....	3.4	3.0	0.9	4.5	22.5	31.2	36.2	37.2	34.2	17.9	6.9	12.4
1886....	5.0	15.0	13.0	13.0	....	....	....	....	....	....	....	....

Lowest: 1882, —1.4 December 21; 1883, 3.3 January 6; 1884, 0.6 April 1; 1885, 0.9 March 17.

MEAN MINIMUM TEMPERATURE.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
1882....	....	....	....	....	....	38.6	45.0	50.7	44.5	33.7	23.5	21.7
1883....	20.9	24.6	21.1	24.0	*29.4	37.6	36.1	48.3	41.3	33.0	27.8	22.8
1884....	21.2	24.0	24.1	26.2	32.5	38.0	43.8	46.0	40.2	32.6	26.5	20.9
1885....	21.7	20.1	23.1	21.9	32.0	38.2	42.9	44.9	42.1	29.6	24.4	22.2
1886....	23.8	24.6	23.8	27.9	....	....	....	....	....	....	....	....

* Mean of 29 observations.

Monthly means of Meteorologic Observations at Bering Island—Continued.

NUMBER OF DAYS OF MINIMUM THERMOMETER BELOW 32°.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1882....	....	....	....	....	....	1	0	0	0	11	26	28
1883....	31	26	30	27	11	0	0	0	1	15	23	30
1884....	31	26	31	26	13	1	0	0	1	10	24	31
1885....	30	26	30	26	11	1	0	0	0	21	25	29
1886....	30	25	29	27	....	....	....	....	....	....	....	....
Means.	30.5	25.8	30.0	26.5	11.7	0.8	0.0	0.0	0.5	14.2	24.5	29.5

Total: 1883, 194 days; 1884, 194 days; 1885, 199 days.

NUMBER OF CLEAR DAYS.

[A "clear" day has no clouds, or less than 0.3 clouds.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1882....	....	....	....	....	....	0	0	3	4	0	1	0
1883....	0	5	0	0	0	0	0	0	3	0	0	0
1884....	0	0	0	0	0	0	1	0	3	0	1	0
1885....	0	0	0	0	0	4	2	3	0	0	0	0
1886....	0	0	0	0	....	....	....	....	....	....	....	....
Means.	0	1.2	0	0	0	1	0.8	1.5	2.5	0	0.5	0

Total number of clear days: 8 in 1883; 5 in 1884; 9 in 1885; annual mean, 7.

NUMBER OF FAIR DAYS.

[A "fair" day has from 0.3 to 0.7 clouds.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1882....	....	....	....	....	....	....	5	5	19	11	17	12
1883....	8	6	8	7	4	4	7	10	12	13	5	14
1884....	2	5	6	8	4	6	5	1	16	12	8	10
1885....	4	4	4	6	16	7	18	11	6	13	12	9
1886....	8	5	7	7	....	....	....	....	....	....	....	....
Means.	5.5	5.0	6.2	7.0	8.0	5.7	8.8	6.8	13.2	12.2	10.5	11.2

Total number of fair days: 98 in 1883; 83 in 1884; 110 in 1885; annual mean, 97.

NUMBER OF CLOUDY DAYS.

[A "cloudy" day has from 0.8 to 1.0 clouds.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1882....	....	....	....	....	....	....	26	23	7	20	12	19
1883....	23	17	23	23	27	26	24	21	15	18	25	17
1884....	29	24	25	22	27	24	25	30	11	19	21	21
1885....	27	24	27	24	15	19	11	17	24	18	18	22
1886....	23	23	24	23	....	....	....	....	....	....	....	....
Means.	25.5	22.0	24.8	23.0	23.0	23.0	21.5	22.8	14.2	18.8	19.0	19.8

Total number of cloudy days: 259 in 1883; 278 in 1884; 246 in 1885; annual mean, 261.

Monthly means of Meteorologic Observations at Bering Island—Continued.

NUMBER OF FOGGY DAYS.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1882	......	......	......	......	......	......	9	10	0	0	0	0
1883	0	0	0	0	2	3	9	10	2	0	1	0
1884	0	0	0	0	0	0	2	0	0	0	0	0
1885	0	0	0	0	0	1	2	1	0	0	0	0
1886	0	0	0	0	......	......	......	......	......	......	......	......
Means	0	0	0	0	0.7	1.3	5.5	5.2	0.7	0	0.2	0

CLOUDINESS, EXPRESSED IN PERCENTAGES.

[The percentage of cloudiness was obtained from the eye estimates of the observer, recorded on a scale of 0 to 10 at each observation. The mean of the three daily observations was used as the mean for the day; 100 per cent represents sky completely overcast.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1882	......	......	......	......	......	......	93	83	60	79	73	78
1883	86	72	86	84	90	92	89	85	73	74	77	78
1884	91	89	88	79	87	81	66	87	65	79	83	81
1885	88	86	90	86	75	75	63	73	86	76	77	80
1886	84	86	86	81	......	......	......	......	......	......	......	......

Annual means: 82 in 1883, 81 in 1884, 80 in 1885.

PERCENTAGE OF RELATIVE HUMIDITY.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1882	......	......	......	......	......	......	......	......	......	......	......	......
1883	......	......	......	......	......	89.9	91.1	93.5	87.9	84.0	85.2	82.6
1884	83.3	84.3	87.4	90.1	88.5	35.1	92.2	91.8	82.4	86.3	90.8	90.2
1885	89.9	93.2	89.3	89.0	89.4	90.3	92.7	92.3	91.5	84.7	90.2	87.0
1886	95.1	92.1	90.0	90.3	......	......	......	......	......	......	......	......
Means	89.4	89.9	88.9	89.8	89.0	88.4	92.0	92.5	87.3	85.0	88.7	86.6

Annual means: 87.7 for 1884, 90 for 1885.

RAINFALL AND MELTED SNOW—AMOUNT OF PRECIPITATION.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July	Aug.	Sept.	Oct.	Nov.	Dec.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
1882	......	......	......	......	......	2.07	1.45	1.07	1.32	3.29	2.23	2.21
1883	0.61	2.98	0.61	1.03	0.38	2.38	1.77	2.25	2.50	2.90	2.20	1.96
1884	0.94	1.49	1.44	1.38	1.31	0.26	2.27	1.71	1.70	3.26	3.39	0.96
1885	0.58	0.39	0.25	0.86	1.19	1.63	4.05	2.15	3.32	1.34	4.08	1.61
1886	0.66	1.50	1.33	1.25	......	......	......	......	......	......	......	......

Total: 21.57 inches in 1883; 20.11 inches in 1884; 21.45 inches in 1885.

NUMBER OF DAYS ON WHICH 0.1 INCH OR MORE RAIN OR SNOW FELL.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1882	......	......	......	......	......	13	18	16	5	13	7	8
1883	20	19	14	18	10	20	20	19	16	16	18	19
1884	12	14	15	12	11	5	13	15	14	20	13	16
1885	18	8	10	7	12	12	12	14	14	12	18	8
1886	13	12	11	9	......	......	......	......	......	......	......	......

Total: 209 days in 1883; 160 days in 1884; 145 days in 1885.

Monthly means of Meteorologic Observations at Bering Island—Continued.

PREVAILING WINDS.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1882	......	......	......	......	......	S.	S.	S.	S. & SW.	N.	NW.	S.
1883	NE.	S.	E.	E	N.	S.	S.	S.	S.	SW. & NW.	SW.	E.
1884	NE.	NE.	N.	N.	S.	S.	S.	E.	SW.	N.	NE.	E.
1885	E.	NE.	NE.	N.	N.	S.	S.	S.	S.	NW.	N.	NE.
1886	NE.	E.	N.	SW.	......	......	......	......	......	......	......	......

MAXIMUM HOURLY VELOCITY (IN MILES).

[Taken from current velocities.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1882	......	......	......	......	......	......	29	......	37	42	45	54
1883	54	41	39	36	34	36	20	47	30	43	44	42
1884	40	48	40	43	26	18	22	40	30	46	37	34
1885	35	43	35	35	38	32	27	......	25	48	37	48
1886	37	26	41	42	......	......	......	......	......	......	......	......

A considerable amount of *snow* falls during the winter. The fierce winter gales usually blow it off the plateaus, forming immense drifts in the valleys and on the lee side of the mountains. In deep shadowy gullies it often remains all summer, and in cold seasons, as for instance 1895, large drifts still remain unmelted as late as September, even at the level of the sea.

Drift ice seems to be of rare occurrence in recent times. I do not know how much reliance can be placed in old Pitr Burdukovski's story to me that formerly, say about 1850, "drift ice was yearly observed coming from the north in large masses." Certain it is that Steller expressly states that during the winter no ice collected in the sea (Ber. Ins., p. 270).

To complete the meteorologic account I may mention that *thunderstorms* are of rare occurrence on the Commander Islands. In 1879, on November 19, Mr. Krebs, after a residence of eight years in the main village on Copper Island, experienced the first thunderstorm. In 1881, on February 8, he records "a stroke of lightning and a short, but strong thunderclap about 7 p. m." Mr. Chernick, in Nikolski, Bering Island, reports "thunder and lightning" on September 12, 1878. I myself observed a thunderstorm passing over Nikolski, September 18, 1882. The first lightning was observed at 9^h 58^m p. m., local time; wind, SW., 13 miles an hour; barometer, 29.552 inches; temperature of air, 52.2° F.; clouds, cumulo-stratus, 8, direction SW.; intervals between first lightning and thunder, 96 seconds; sixth thunderclap (10^h 25^m p. m.), 12 seconds after lightning; tenth, 40 seconds; eleventh lightning before thunder of tenth. This was the last distinct thunder heard, 10^h 35^m p. m. After that continued distant lightning lit up a narrow strip along the northern horizon. No lightning seen after 11^h 10^m p. m.

Aurora borealis is equally scarce. At Nikolski, on November 15, 1882, I observed a faint northern light at 12^h 30^m a. m., local time, extending to about *η Urs. majoris*. On November 17, 1882, I observed another at 10^h 40^m p. m., local time, consisting of a uniform greenish white light below, above which most of the time a large rosy space was seen filling the arch between *γ* and *η Urs. majoris;* a similarly colored but often

broken arch extended through the constellations of *Cygnus*, *Cassiopeia*, *Gemini*, and *Auriga*, sometimes fainter, sometimes more fiery, especially in *Cygnus*. Very seldom the red color filled the space between the rosy spot below *Ursa major* and the upper arch, and then only for a few seconds. At 11 p. m. the sky became so overcast as to cut off further observation.

Corresponding observations made at St. Paul Island, Pribylof group, from 1872 to 1883, and published by the United States Weather Bureau (Fur Seal Arb., II, App. pp. 591–593), afford means of exact comparison between the Russian and the American seal islands, except as regards mean temperature, the latter being obtained on St. Paul from observations made at 7 a. m., 2 p. m., and 9 p. m.

But even a comparison of the *mean temperature* affords several very interesting results. Thus, while the annual means apparently differ but slightly, there is also the same relative proportion between the various months from December to September. But while the figures representing the mean temperatures for these months are higher on Bering Island than on St. Paul, those of October and November are higher on the latter. The chief exception from the relative proportion between the months is shown by the mean temperatures of August, which is about 4 degrees higher than July and September in Bering Island, but only about 2 degrees in St. Paul.

Turning now to the *maximum temperature*, it will be seen to be 63° F. in Bering Island as against 62° on St. Paul. But on the other hand, while the *minimum temperature* in Bering Island was hardly ever below zero during the four years of observation, it often drops below that point in St. Paul. Thus, the difference between the summer and winter extremes is less on Bering Island than on St. Paul.

Coming now to the question of *cloudiness*, it will be seen that while the annual percentage is almost identical, the monthly distribution is radically different. Thus, while in St. Paul Island there are five times as many clear days during November to April as during May to October, on Bering Island the proportion is reversed, there being four times as many clear days during the latter period as during the former. Of fair days, St. Paul enjoys nearly twice as many during the above six winter months as during the six summer months, while Bering Island has a good many more fair days in summer than in winter. Consequently, the entirely overcast days preponderate on St. Paul in summer, while on Bering Island their number is greater in winter. The latter island, moreover, has about 10 per cent more overcast days during the whole year, but on the contrary also about 10 per cent less overcast during the summer months, or during the time the seals remain on the islands.

Unfortunately the percentage of *relative humidity* is not given for St. Paul Island. A glance at the table for Bering Island will show how excessively humid the climate of the latter is, the annual means reaching 90 per cent, the monthly means occasionally exceeding 95 per cent, and never lower than 82 per cent. The months showing the greatest percentage of relative humidity are July and August.

The Weather Bureau tables alluded to do not contain any data relating to *precipitation* on St. Paul Island, and all the published information I have been able to find relates only to the months May to November.[1] Compared with the corresponding tables for Bering Island, they show that the precipitation on the latter island is considerably smaller during that period than on St. Paul Island.

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[1] Fur Seal Arb., VIII, pp. 518–519.

FAUNA AND FLORA OF THE COMMANDER ISLANDS.

The animals and plants of the Commander Islands have been studied since Steller set foot on the virgin ground of Bering Island in 1741. He collected and described all the new things he saw, and if he had lived to elaborate his collections and finish his work, but little would have been left for his successors. Since then Vosnessenski has been on the island; Dr. Dybowski collected during various visits between 1879 and 1883; Nordenskiœld's *Vega* expedition, with his admirable staff of scientists, Nordquist, Kjellman, Stuxberg, and Almquist, used their five days' stay in 1879 exceedingly well; and, above all, Mr. Grebnitski has devoted work, time, and money during nearly twenty years to enrich the Russian museums, particularly that of the Imperial Academy of Sciences in St. Petersburg, with extensive and costly collections of natural history. The United States National Museum is also indebted to him for valuable material. Finally, during my stay in 1882–83, and to a less extent in 1895, I myself have been able to add my mite to our knowledge of the flora and fauna of these islands, nearly all my collections being now in the United States National Museum. Yet the subject is not exhausted; many animals and plants occurring there remain uncollected, while many of the collections in the museums await the arrival of the specialist to work them up.

Lack of time and space prevents more than the briefest possible résumé of the subject in the present connection; a more exhaustive treatise would make a book in itself. There is abundant evidence in the material at hand to show that the islands during the period previous to which they received their present fauna and flora were totally covered by the sea, and that since that time they have not been connected with the mainland on either side. From this it follows that the animals and plants are not truly indigenous, though I have no doubt that many of the numerous species described as new from these islands are really peculiar, and not found elsewhere; but in that case their origin on the islands is undoubtedly due to comparatively recent isolation. The sporadic character of the fauna and flora as shown in the great number of genera in proportion to the species, as well as the absence of many forms which, from their general distribution, would be expected to occur, is clearly indicative of the accidental immigration of the component species. They evidently immigrated, especially and more regularly from the west, from Asia, by means of prevailing winds—currents and driftwood carried by these—and more seldom from the east, from America. That such inhabitants as are more independent of the above agencies likewise show nearer relationship to the Asiatic fauna is partly due to the shorter distance and partly to the well-known effort of the Asiatic fauna to extend beyond its own limits.

As might be expected from their location, the islands are chiefly palæarctic in their bio-geographical relations, with a fair sprinkling of circumpolar, American, and North Pacific forms. The marine fauna and flora partake more particularly of this latter character, and it is probable that Dr. W. H. Dall's conclusions, derived from a study of the mollusks, applies to most of the other marine animals, viz:

> The fauna of Commander Islands, as far as known, is intimately related to the general Arctic fauna and especially to the Aleutian fauna, somewhat less so to the Kamchatka fauna, but presents in itself nothing distinctive. While the faunal aspect of the mollusca is boreal, there is a number greater than might be expected of species common to Japan and California.

To this statement he afterwards added the note:

> The connection with Japan is rather that the northern forms extend southward into Japan than that any characteristic Japanese forms extend north. (Proc. U. S. Nat. Mus., IX, 1886, p. 219.)

MAMMALS.

The chief zoological interest centers in the four marine mammals revealed to the scientific world in Steller's famous treatise "De Bestiis Marinis" (Novi Comm. Ac. Sc. Imp. Petrop., II, 1751, pp. 289–398, pls. XIV–XVI), which must always remain a monument to the learning and industry of its author. In this he described for the first time the sea-cow, the sea-lion, the fur-seal, and the sea-otter.

Of these, the sea-cow (*Hydrodamalis gigas*, also known as *Rytina gigas* or *stelleri*) possesses greatest interest, on account of its early extermination by man, which took place in 1768, twenty-seven years after its discovery. The sea-cow was an herbivorous animal, anteriorly shaped somewhat like a seal, but with a large caudal fin like that of a whale or fish, but no hind legs, and belonging to the mammalian order of *Sirenia*, the few living relations of which, the manati and dugong, now only inhabit the tropical waters of both hemispheres. There is no indisputable evidence of its having ever inhabited other coasts than those of the Commander Islands, as the find of a rib on Attu Island does not necessarily prove that the animal once lived there, though that is not improbable. The history of this animal, imperfectly known as it is, fills volumes, and all we can do in the present connection is to refer to some of the more recent literature (Büchner, Die Abbildungen der nordischen Seekuh, Mém. Ac. Imp. Sc. St. Petersb., 7 ser., XXXVIII, 1891, No. 7.—Stejneger, Proc. U. S. Nat. Mus., 1883, pp. 78–86; 1884, pp. 181–189.—Stejneger, On the Extermination of the Great Northern Sea Cow, Am. Geogr. Soc. Bull., No. 4, 1886, pp. 317–328.—Stejneger, How the Great Northern Sea Cow (*Rytina*) Became Exterminated, Amer. Natural., XXI, Dec., 1887, pp. 1047–1054).

The sea-lion (*Eumetopias stelleri*) was formerly quite abundant, but has now become nearly extinct on both islands, though still numerous in certain localities on the Kamchatkan coast. In 1895 I saw only one individual on Sivutchi Kamen at the North Rookery, Bering Island.

The fur-seal (*Callotaria ursina*) being the chief subject of this report, needs no further mention in this connection.

The fate of the sea-otter (*Latax lutris*) in the Commander Islands is highly instructive and interesting. When Bering and his unfortunate followers landed on Bering Island they found the sea-otters so numerous that these animals furnished food for the entire crew during the whole winter. On their return to Kamchatka the following year (1742) they brought with them more than 700 skins of this costly fur. Then followed a period of reckless slaughter of these animals by the rapacious promyshleniks. Thus, in 1745, Bassof and Trapeznikof secured 1,600 skins; in 1748 about 1,350 were killed. The result was that within a very few years the sea-otter almost disappeared from Bering Island, for Tolstykh's expedition obtained only 47 during the winter of 1749–50; Drushinin's men, in 1754–55, took only 5; while in the account of Tolstykh's second expedition, winter 1756–57, it is expressly said that "no sea-otters showed themselves that year." It is interesting to note that even in those days Copper Island offered a safer retreat for the sea-otter, since Yugof, who also visited that island, returned home in 1754 with 790 skins.

While not actually and literally exterminated on Bering Island—Trapeznikof's expedition of 1762–63 secured 20 otters there—it did not become common there again, except possibly during an alleged sudden reappearance in 1772, until after the abandonment of the island, when the Russian-American Company was organized. Upon

the recolonization of the island the otters were found common in places; thus it is said that in 1827 no less than 200 otters were killed in one week at the Reef near the present Nikolski village (Slunin, Promysl. Kamch. Sakh. Komand. Ostr., 1895, p. 103). But the reckless slaughter of former days was resumed and the sea-otter long ago ceased to be a regular inhabitant of that island. Occasionally a solitary individual strays over from Copper Island, where the same careful management which resulted in the increase of the fur-seal has succeeded in preserving and increasing the sea otter to such an extent that I believe there is no other place in the world where so many sea-otters can be seen at the present day. The condition of the herd is now such that 200 animals can be killed off yearly without detriment. The places where the sea-otter have their rookeries are constantly guarded, to keep intruders off. Shooting, making fire, or smoking is strictly prohibited near these places. Only nets are now used to capture the otters; and if any females or yearlings are caught alive they must be set free. The number to be taken is determined in advance by the administration, and the hunting expeditions of the natives are undertaken in common, under the leadership of the chief, though each hunter keeps the otter he secures. They are taken off their hands by the Russian Government at a certain fixed price.

Of other marine mammals occurring at the Commander Islands, we may further mention four species of hair-seals, viz, *Phoca largha*, *fœtida*, *grœnlandica*, and *fasciata*; three species of ziphioid whales, viz, *Ziphius grebnitzkii*, *Berardius bairdii*, and *Mesoplodon stejnegeri*; a sperm whale (*Physeter macrocephalus*); several delphinoid whales, among which the terrible enemy of the fur-seal, the killer (*Orca gladiator*), as well as several species of fin-back whales.

The land mammals are few, the most important being the Arctic fox (*Vulpes lagopus*). These animals, which are now fairly common, yielding a handsome income to the natives, belong almost exclusively to the dark-bluish phase. Their economic importance will be treated of elsewhere in this report.

There are two rodents on Bering Island, but both have been introduced by the agency of man during late years. *Mus musculus*, the common house-mouse, was brought to Bering Island in 1870 by the schooner *Justus*, in a cargo of flour. The short-tailed red field-mouse (*Microtus rutilus*), which now overruns the islands in vast numbers, was introduced from Kamchatka at a much later date, probably with the firewood. This is probably also the origin of the bats (*Vespertilio?*) which are said to have been seen at Nikolski during the last couple of years.

The introduction of the reindeer (*Rangifer tarandus*) will be mentioned elsewhere (p. 33).

BIRDS.

I have reported upon the birds in a separate volume (Results of Ornithological Explorations in the Commander Islands and in Kamtschatka. By Leonhard Stejneger. Bull. No. 29, U. S. Nat. Mus. 1885; 382 pp. + 8 plates) and in a later supplementary paper (Revised and Annotated Catalogue of the Birds Inhabiting the Commander Islands; Proc. U. S. Nat. Mus. 1887, pp. 117–145 + 3 plates), to which I would refer the reader for detailed information. In the last-mentioned paper I enumerated 143 species of birds as having been collected in the Commander Islands. To these I can now add three species, viz: (1) *Gavia alba*, the ivory gull, a specimen of which Mr. Grebnitski presented to me (U. S. Nat. Mus., No. 151983); (2) *Eurynorhynchus pygmæus*, the spoon-bill sandpiper, two specimens of which were shot during the latter part of

September, 1894, and sent by Grebnitski to the museum in St. Petersburg; and (3) *Milvus melanotis*, the black-eared kite, a mere straggler, taken once on Bering Island. The specimen was presented to the *Vega* expedition by Mr. Grebnitski (Palmén, Vega Exp. Vetensk. Iaktt., v, 1887, p. 294).

One of the Commander Island birds (*Phalacrocorax perspicillatus*) deserves at least a passing notice, not only because we know of no other locality in which it has with certainty occurred, but because it has become extinct within recent years through the agency of man. The history of this rare bird (only 4 specimens exist in museums) is traced and full description given by me in a separate paper (Contribution to the History of Pallas's Cormorant; Proc. U. S. Nat. Mus., XII, 1890, pp. 83–88). In 1882 I fortunately disinterred a number of bones of this bird, which have been described and figured by Mr. F. A. Lucas (*tom. cit.*, pp. 88–94, pls. II–IV). An additional collection made by me in 1895 will also shortly be elaborately described and figured by him. A preliminary note may be found in *Science*, November 15, 1895, p. 661.

FISHES.

A collection of littoral and river fishes occurring at the Commander Islands, brought together by Mr. Grebnitski and myself, is now being reported upon by Dr. Tarleton H. Bean. The report will be published in the Proceedings of the United States National Museum, as No. 11 of the "Contributions to the Natural History of the Commander Islands."

TUNICATES.

Styela arctica has been described by Swederus (Vega Exp. Vet. Iakt., IV, 1887, p. 108) as a new species from Bering Island.

INSECTS.

Mosquitos are numerous on Bering Island and very annoying on the few otherwise pleasant days of which the summers of that region can boast. *Geometridæ* and *Microlepidoptera* are rather numerous, *Noctuidæ* less so. I have only seen one specimen of diurnal Lepidoptera, viz, a butterfly very much like *Vanessa urticæ*. Of the Coleoptera, the large staphylinid, *Creophilus villosus*, is very numerous on the seal-killing grounds. Mr. John Sahlberg has reported upon a few (9) Coleoptera and (1) Hemiptera collected by the *Vega* expedition (Vega Exp.Vet. Iakt., IV., 1885, pp. 61–68), one of which is described as new, viz, *Anisotoma abbreviata*, one of the *Siphidæ*. My own collections are considerably larger and contain (besides the Microlepidoptera), according to a preliminary census by Mr. M. Linell, 46 species, of which 33 are Coleoptera. These include all of Sahlberg's species except *Oxypoda opaca* and *Anisotoma abbreviata*, so that the Coleoptera from the Commander Islands now number 35 species. Of these, no less than 12 species belong to the *Staphylinidæ*. The other orders are represented by 2 species of *Hemiptera*, 5 *Diptera*, 3 *Hymenoptera*, 1 *Siphonaptera*, and 1 Lepidopter, viz, *Agrotiphila alaskæ* Grote.

It should be remarked that the insects collected of late years in the neighborhood of the main villages must not be given too great weight in determining the zoological relationship of the islands, for many have undoubtedly been introduced recently from Petropaulski, Kamchatka, in the large quantity of firewood shipped to the islands every year. In fact, some of the species collected by me in 1895 were taken on or near the wood-pile.

MYRIAPODS.

The three species brought home by me have been determined by Bollman. *Linotænia chionophila* and *Lithobius sulcipes*, both from Bering Island, are known from other localities, but the species described by him as new, under the name of *Lithobius stejnegeri*, is the only one thus far found only on the Commander Islands (Bull. U. S. Nat. Mus. No. 46, 1893, p. 199).

ACARIDS.

The acarids collected by the *Vega* expedition have been described by Kramer and Neuman (Vega Exp. Vet. Iakt., III, 1883, pp. 519–532, pls. XLI–XLIV). No less than 5 new species were described from Bering Island, 4 of which were found only on the latter, as follows: *Nesæa arctica*, *Bdella villosa*, *Ixodes borealis*, *I. fimbriatus*, and *Gamasus arcticus*. Of these I obtained only *I. borealis*.

SPIDERS.

It was my intention to get as nearly complete a collection of spiders as possible, and I succeeded in obtaining quite a number of species, which were turned over to the United States National Museum. They were lent to the late Dr. Marx to be determined, but the report was not finished before his death.

CRUSTACEANS.

The crustaceans collected have not been worked up as yet, except the entomostraca, which have been described by Prof. W. Lilljeborg, of Upsala, Sweden (On the Entomostraca collected by Mr. Leonhard Stejneger, on Bering Island, 1882–83. Proc. U. S. Nat. Mus., X, 1887, pp. 154–156). Five species were collected, of which I found *Branchipus paludosus*, *Daphnia longispina*, and the new species *Diaptomus ambiguus*, in small fresh-water ponds at Ladiginsk, Bering Island. The other new species is *Eurycereus glacialis*, which, however, has also been found in Greenland and Vaigatch Island, at the entrance to the Kara Sea.

The crabs have been identified by Mr. J. E. Benedict, as follows: *Oregonia gracilis* Dana; *Telmessus cheiragonus* (Tilesius); *Eupagurus gilli* Benedict; *Eupagurus hirsutiusculus* (Dana); *Eupagurus middendorfii* Brandt; *Eupagurus nudosus* Benedict; and *Hapalogaster grebnitskii* Schalfeef, recently described from Bering Island (Bull. Acad. Sc. St. Petersb., XXXV, No. 2, 1892, p. 335, fig. 3). Schalfeef identifies another species of *Hapalogaster*, also collected by Mr. Grebnitski on Bering Island, as *H. mandtii*.

MOLLUSKS.

Among the invertebrates, the mollusks have been most extensively collected and most thoroughly reported upon. The *Vega* expedition obtained 26 species, Mr. Grebnitski sent the National Museum 23 species, and I myself 45 species, out of a total of 75 species thus far collected. Of these, 10 are land or fresh-water species. Dr. W. H. Dall has published two reports upon the Commander Islands collections (Proc. U. S. Nat. Mus., VII, 1884, pp. 340–349; and IX, 1886, pp. 209–219). In the last paper he gives a full list of the species, including those of the *Vega* expedition which have been reported upon by Westerlund and Aurivillius. The species of land and fresh-water mollusks thus far collected on the islands are: *Limax* (*Agriolimax*) *hyperboreus*; *Vitrina exilis*; *Hyalina radiatula*; *Conulus fulvus*, var.; *Patula ruderata*, var. *pauper*;

Pupilla decora and *arctica; Acanthinula harpa; Limnæa ovata; L. humilis; Pisidium æquilaterale.* The new species described from Bering Island by Aurivillius is *Pleurotoma beringi;* and by Dall, in his first paper, *Lacunella reflexa* (p. 344, pl. II, figs. 1–3), *Cerithiopsis stejnegeri* (p. 345, pl. II, fig. 4), and *Strombella callorhina* var. *stejnegeri* (p. 346, pl. II, figs. 5, 6).

WORMS.

At least one species of earthworm occurs, and several leeches, but, like the rest of the lower invertebrates collected, they have not been reported upon as yet. Wirén has described a new species of chætopod from Bering Island, viz, *Potamilla neglecta* (Vega Exp. Vet. Iakt., II, 1883, p. 422).

SPONGES.

A new variety (*arctica*) of *Esperia lingua* has been described from Bering Island (5–10 fathoms) by Fristedt (Vega Exp. Vet. Iakt., IV, p. 449, pl. XXV, figs. 20–24; pl. XXIX, fig. 18).

PLANTS.

It was quite to be expected that Steller, as an expert botanist, should have made extensive botanical collections on Bering Island, and as he seems to have collected 211 species of plants there (see Pennant, Arct. Zool., Suppl., 1787, p. 38), he gathered more species than any of the various collectors who visited the island afterwards. Thus the combined collections of Dybowski, Wiemuth, and Kjellman include 144 phanerogams, while I have brought home nearly exactly the same number of species. The combined number of species, however, is much greater. Dr. Kjellman has published an interesting account of the flora as revealed in the first-mentioned collections (Vega Exp. Vet. Iakt., IV, 1887, pp. 281–309), while the late Prof. Asa Gray, in 1885, reported upon my collections in the Proceedings of the United States National Museum, VII, pp. 527–529, to which paper I added a few remarks (*ibid.*, pp. 529–538). During my trip in 1895 I had but scant time and facilities for collecting plants, and I confined myself chiefly to an unsuccessful search for *Cassiope oxycoccoides* in the exact locality and about the same season as I had collected it in 1882. Nevertheless, I was able to add a few species to the flora, which Dr. J. N. Rose, of the National Herbarium, has kindly determined for me as *Carex rariflora*, *Kœnigia islandica*, and *Ranunculus hyperboreus.* From the lists published it should now be possible to compile a tolerably complete flora of Commander Islands phanerogams.

Dr. Asa Gray described one of my ericaceous plants as new, viz, *Cassiope oxycoccoides*, and the late Dr. George Vasey afterwards determined one of the grasses to be new and named it *Alopecurus stejnegeri* (Proc. U. S. Nat. Mus., X, 1887, p. 153; figured as fig. 2, pl. XXIV, Grasses Pacif. Slope, by Vasey, pt. I, 1892). As these species have not as yet been recorded from other localities they must be regarded, provisionally at least, as peculiar to the Commander Islands, and Dr. Kjellman's statement to the contrary effect (*tom. cit.*, p. 286) must be modified accordingly.

Dr. Kjellman's concluding remarks (*tom. cit.*, p. 289) are so interesting and important that I venture to translate them here, as follows:

> The flora of the Commander Islands is chiefly composed of two elements. One of these consists of species not entering the present Arctic region, or at any rate not to be regarded as belonging to the characteristic plants of this region. Most of these have their chief range of the present day extending over the islands and coasts of the Northern Pacific Ocean. These form the bulk of the vegetation

and determine its character. I regard them as arcto-tertiary species, of which many, at least, have formerly had a wider distribution than at present.

The other element consists of species which by their present distribution are indicated as arctic-alpine. Several of these are to be regarded as among the characteristic plants of the present Arctic regions.

The Commander Islands, with the other Aleutian Islands, compose a floral district which forms a transition chiefly between three other districts, viz, the Manchu-Japanese, the Americo-Pacific, and the Arctic district, although less closely related to the latter than to the other two, the northern outpost of which it may be regarded to represent.

Dr. Ernst Almquist has investigated the lichens of Bering Island and has published a very interesting account of his studies (Vega Exp. Vet. Iakt., IV, 1887, pp. 518–519, 521, 524–531), in which he gives an ingenious explanation of the curiously sculptured surface of the heath-like plant covering of the lower plateaus as due to a natural rotation of the plants composing it.

The general character of the flora is very much like that of the treeless regions of Northern Europe, the most discrepant features being the splendid rhododendrons (*R. kamtschaticum* and *chrysanthum*) and the beautiful dark-maroon-colored Saranna-lily (*Fritillaria camtschatcensis*), the bulbs of which the natives gather for food in late summer. These plants indicate the close relationships to the flora of Kamchatka and the other Aleutian Islands. The plants of both islands are in most cases identical, but the manner of their immigration very likely has caused the occurrence of some species in one island which are absent in the other. Thus I have from Copper Island the conspicuous yellow flowering *Viola biflora* (also found by me at Petropaulski), which I failed entirely to find on Bering Island, and which I could scarcely have overlooked.

The islands are completely destitute of trees, the few species of *Salix*, *Pyrus*, and *Betula* hardly ever rising above 6 to 8 feet, though I have a section of *Betula eversmanni* from Bering Island, with a diameter of 2 inches at the root. The *Pyrus*, in many places, forms extensive, nearly impenetrable thickets.

There are two tolerably well-defined belts of vegetation on the island, one a very luxuriant growth of higher plants in the lower valleys and plains, the other a heath-like formation above the former.

The luxuriance of the vegetation in the lower belt, due to a rich soil and extreme moisture, is marvelous. Some species familiar to me from boyhood I could hardly recognize in the enormous specimens before me. Such plants as *Anemone narcissiflora* and *Geranium erianthum* sometimes reach a height of 3 feet, while in some particularly favored localities many acres of ground may be found covered with an almost impenetrable jungle of *Archangelica*, *Heracleum lanatum*, *Artemisia tilesii*, *Picris japonica*, *Spiræa kamtschatica*, *Aconitum*, *Veratrum album*, etc., often reaching a height of 5 to 6 feet. The exuberance of the umbellifers, particularly near the coast, is very striking, as shown in the accompanying photograph of *Heracleum lanatum* (pl. 15*a*). Near the beach this belt shows the usual influence of the neighborhood of salt water in the presence of such plants as *Lathyrus maritimus*, *Mertensia maritima* and *Ligusticum scoticum*.

The heath commences often quite abruptly above this belt, covering the surface of the beach terraces and the lower plateaus. Its presence does not depend so much upon the altitude as the character of the ground, for where the coast escarpment is low the heath formation commences even at an altitude of 20 to 30 feet. The funda-

mental plant of this formation is *Empetrum nigrum*, richly interspersed with *Loiseleuria procumbens*, *Cassiope lycopodoides* and other ericaceous plants, chiefly *Bryanthus*, and in the lower portions *Rhododendron chrysanthum*. Where the ground is marshy the salmon berry, *Rubus chamæmorus*, is rather common. Higher up on the mountain sides the vegetation grows more and more scanty and alpine in character.

The *pelagic flora* around Bering Island has been studied by Dr. F. R. Kjellman (Kgl. Svenska Vetensk. Akad. Handling., (n. s.), XXIII, 1889, No. 8, 58 pp., 7 pls), who observes that at Bering Island all conditions are found favorable to the development of a rich flora of *algæ* of the pelagic type. "It may even be said with safety that there are but few parts of the ocean the flora of which exceeds or even approaches that around Bering Island, in so far as multitude of individuals or number of magnificent forms are concerned."

NATIVE POPULATION OF THE COMMANDER ISLANDS.

The Commander Islands, when discovered in 1741, were uninhabited, and no trace of any former population has been found. For over 80 years the islands remained without a regular population, although they were visited almost yearly up to the end of the eighteenth century by numerous parties of Russian fur-hunters, or promyshleniks, as they are called. In the early days it was the custom of these hardy frontiersmen to pass the first winter on Bering Island in order to secure provisions of sea-cow meat for their further expeditions. Sometimes the crews of several vessels wintered there at the same time, in one year at least (1754–55) numbering over 100 men. Those were gay days on Bering Island, when the sea cow, the sea-otter, the blue fox, and the fur-seal were still plentiful. But these precious animals were soon exterminated, literally, as the sea-cow, or commercially, as the three other species, and the inhospitable and dangerous shores of the Commander Islands were but seldom visited by sailors or hunters.

When the colonial district of Atkha was established by the Russian-American Company, in 1826, it was decided to locate a number of natives from the other Aleutian Islands, and consequently two colonies of Aleuts and half-breeds, the offspring of Russian promyshleniks and Aleut women, were planted on Bering and Copper islands. A similar colony, located on the Kuril Islands, was made up mostly from natives of the Kadiak district. The colony of Bering Island consisted chiefly of natives of Atkha Island, or the Andreanovski group, in general, while the Copper islanders were made up mostly of men and women from Attu. Although the inhabitants of the two islands by transfer and intermarriage have become considerably mixed of late, yet the difference in origin is still traceable in the dialects spoken, the Atkha people still preponderating on Bering Island, the Attu islanders on Copper Island.

Of late years two other elements have been added to the native population. As noted above, the Russian-American Company had located a colony of natives, mostly from the Kadiak district, on the Kuril Islands. When the latter islands were ceded to Japan these natives and their offspring declared their intention of remaining Russian subjects and were transferred to Kamchatka. After a miserable existence for several years in a small village outside of Petropaulski, they were located on the east coast near Cape Lopatka, in order to hunt sea-otters. Their village was situated in a

small bay just back of Cape Zholti.[1] They did not do well there, and during the last few years (1888) were transferred to Bering Island, their number helping to swell the total of the Commander Islands population. This was not a very desirable addition, however, and has not resulted in elevating the morals of the former inhabitants.

The other addition consists in a number of girls from Petropaulski. It was found that the inbreeding of the natives on the two islands was not only having a deleterious effect upon the health and vitality of the community, but intermarriage had made the inhabitants so interrelated that it was difficult to find people who could be married at all without violating the intricate laws of the Russian Church governing marriage between relatives. Under these circumstances a number of unmarried young men from both islands were encouraged to go to Petropaulski and provide themselves with brides.

The following tables of the population on the islands are derived from various official returns, published and unpublished. The figures for 1860 are from Tikhmenief's book. The figures for 1895 have been mislaid, but the total for both islands is believed to be about 650(?). The tables are meant to show only the native population, and not to include those temporarily living there, as the administrator, his assistant, the doctor, the midwife, the priests, the deacon, the kossaks and soldiers, the company's agents, or their families. They would increase the total about 20; and the entire population of the Commander Islands in 1895 may therefore be set down as about 670 of both sexes.

Native population of Commander Islands, 1860 to 1892.

Year.	Bering Island.			Copper Island.			Total, both islands.
	Male.	Female.	Total.	Male.	Female.	Total.	
1860			300			90	390
1870	126	111	237	80	73	153	390
1875	139	132	271	90	81	171	442
1880	164	145	309	91	101	192	501
1881			310			203	513
1883	164	155	319	93	114	207	526
1892			336			300	636

Apart from the sudden increase, due to the importation of the Zholti Mys natives, a pretty steady, though slow, increase of the population is noticeable since 1870. This is rather interesting in a mixed population of but indifferent vitality and, moreover, afflicted by a tendency to scrofulous and pulmonary diseases, the more so since a couple of rather severe epidemics of influenza and scarlet fever have swept over the islands of late years.[2] The question of the movement of this population during the years 1868 to 1881 has been studied by Dr. B. Dybowski,[3] whose tables relating to births and deaths are interesting enough to deserve a place in this connection.

[1] I have partly traced the history of these natives in an article in *Science* (n. s. II, July 19, 1895, pp. 62–63). When that was written, I little thought that on the very day of its publication I should be living among these same natives on Bering Island.

[2] As a result, the native population of Bering Island, according to Dr. Slunin (Prom. Bog. Kamch., etc., p. 57), between 1886 and 1891 suffered a decrease of 16, there being 111 births only against 127 deaths. His statement, however, that the population of Copper Island has not increased during the 20 years from 1872 to 1892 is not in conformity with the facts as shown in the above table.

[3] Wyspy Komandorskie, pp. 78–87.

Number of births and deaths on Commander Islands, 1868 to 1881.

Year.	Bering Island.						Copper Island.						Total, both islands.	
	Births.			Deaths.			Births.			Deaths.				
	Male.	Fem.	Total.	Male.	Fem.	Total.	Male.	Fem.	Total.	Male.	Fem.	Total.	Births.	Deaths.
1868	2	4	6	6	9	15	0	0	0	3	1	4	6	19
1869	4	2	6	4	13	17	2	3	5	0	0	0	11	17
1870	9	4	13	3	7	10	3	5	8	0	2	2	21	12
1871	5	3	8	3	1	4	2	2	4	0	0	0	12	4
1872	7	9	16	6	4	10	3	2	5	1	0	1	21	11
1873	7	7	14	3	0	3	2	2	4	1	3	4	18	7
1874	8	10	18	3	3	6	6	6	12	0	5	5	30	11
1875	5	6	11	4	6	10	2	6	8	3	2	5	19	15
1876	8	6	14	2	2	4	5	6	11	4	2	6	25	10
1877	10	5	15	3	8	11	4	6	10	6	1	7	25	18
1878	6	9	15	2	5	7	5	7	12	4	0	4	27	11
1879	11	12	23	2	5	7	3	6	9	6	4	10	32	17
1880	6	8	14	7	7	14	7	4	11	3	2	5	25	19
1881	7	7	14	9	3	12	6	5	11	5	5	10	25	22
Total	95	92	187	57	73	130	50	60	110	36	27	63	297	193

Births and deaths on Commander Islands, according to months, from 1868 to 1881.

Months	Births.									Deaths.								
	Bering Island.			Copper Island.			Both islands.			Bering Island.			Copper Island.			Both islands.		
	Male.	Female.	Total.	Male.	Female.	Total.	Male.	Female.	Total.	Male.	Female.	Total.	Male.	Female.	Total.	Male.	Female.	Total.
January	3	12	15	3	5	8	6	17	23	4	3	7	2	0	2	6	3	9
February	5	4	9	2	6	8	7	10	17	2	3	5	1	2	3	3	5	8
March	6	3	9	6	4	10	12	7	19	2	3	5	0	2	2	2	5	7
April	3	4	7	2	8	10	5	12	17	3	1	4	2	3	5	5	4	9
May	7	5	12	8	3	11	15	8	23	6	4	10	0	1	1	6	5	11
June	7	9	16	4	4	8	11	13	24	1	17	18	1	5	6	2	22	24
July	4	7	11	3	4	7	7	11	18	2	4	6	3	0	3	5	4	9
August	6	8	14	2	0	2	8	8	16	5	9	14	8	2	10	13	11	24
September	10	9	19	5	3	8	15	12	27	7	5	12	6	2	8	13	7	20
October	17	8	25	5	7	12	22	15	37	4	2	6	3	3	6	7	5	12
November	7	9	16	1	5	6	8	14	22	6	4	10	3	0	3	9	4	13
December	8	3	11	3	6	9	11	9	20	4	5	9	2	0	2	6	5	11
Month unknown	5	4	9	0	0	0	5	4	9	2	10	12	0	2	2	2	12	14
Total	88	85	173	44	55	99	132	140	272	48	70	118	31	22	53	79	92	171

The Commander Islanders, being derived from the other Aleutian Islands, do not differ from their relatives now under American authority in any essential point, and they naturally possess the characteristics, both good and bad, of the latter. By nature gentle, intelligent, and honest, the worst of their present vices have been acquired by contact with white men. I have spent twenty months among them, and I have only the most pleasant recollections of these simple-hearted people.

Notwithstanding their common origin, there is a marked difference between the natives on Bering Island and those on Copper Island. The former are more reticent, less ambitious, and, therefore, to most people, less attractive than the latter, whose gaiety and whim make a very favorable impression on the visitor. This difference seemed more marked during my visit to the islands last year than on the former occasion, and, on the whole, it seemed as if the Bering Islanders had deteriorated. Even theft was not uncommon among the younger generation on Bering Island—though an almost unknown thing fourteen years ago. But even now real criminal offenses are not frequent. Occasionally a serious offender has to be sent to Vladivostok for punish-

ment, but ordinarily deportation from one island to the other, extra service at the South Rookery, or fines, are resorted to. The kossaks have often to arrest disturbers of the peace, resulting from the general spree on the great holidays, or *prasniks;* but a night's lodging in the lock-up sobers them up, and neither island has thus far needed a jail. As an illustration of the patriarchal ways of justice in vogue not many years ago the following literal abstract from the station log of Bering Island is both instructive and amusing:

DECEMBER 3, 1877.—A married woman was on trial for stealing a petticoat from a clothes-line. As she would not confess, the judges (natives) took two pieces of paper, on one of which was written "I have stolen," and on the other "I did not"; and it happened that she drew the one with the inscription "I have stolen." She was sentenced to wash the floor in the church.

The moral decline of the people I attribute largely to the recent introduction of intoxicating liquors. In 1882 it was forbidden the natives both to import spirits and to brew "beer" of sugar. As a result they were tractable and contented, except as to this particular point. I was then told a story, the literal truth of which I can not guarantee, however, but it is to the point: A "revisor" arrived at the island to inquire if the natives were treated well, and he called a meeting to receive any complaints that they might have to make. The chief, after consulting with the other men, finally declared that they had absolutely nothing to complain of except the discrimination made against them, among all the children of the tsar, that they were not allowed to get drunk on the great church and state holidays, and that they were not conscious of any conduct which would merit such an unusual and severe punishment.

Whether this petition had any weight, or whether the American Company, which had been instrumental in establishing the prohibition, was losing its influence, I don't know; certain it is that at my second visit to the islands the natives were allowed to import and consume many hundred dollars' worth of alcohol, the result being the usual one.

Until within the last few years the condition of these natives has been the enviable one of being the richest and most prosperous community in Bering Sea, or along any of its shores. Not only the increase in the number of seal skins taken, and later on the increased payment for the skins when the number began to fall off, contributed to this end, but also the flourishing condition of the sea-otter and blue-fox hunt, due to the enforcement of wise regulations for the protection and chase of these animals.

The sea-otter long ago became extinct on Bering Island, but on Copper Island it is still common. The "rookeries" or breeding-places of this valuable animal, which furnishes the costliest of all furs,[1] are guarded and protected with jealous care. The animal, which is now nearing its extermination on all the American islands and shores, where it is not protected at all, is actually increasing on Copper Island, and yields, besides a handsome return to the Government, sufficient income to keep the natives in comparative affluence, as this island can easily produce 200 skins a year. The sea-otter is there hunted by the natives in common, but the individual hunter secures the price for the animal he catches. Only nets are allowed in their capture. The Government buys all the skins from the natives at a certain fixed rate, 140 rubles for the first quality, 75 rubles for the second, and disposes of them to the company as per contract.

[1] A single first-class sea-otter skin brought at auction in London, spring of 1895, $1,100.

The following table, based upon official returns, shows the gradual increase until the present capacity of the island, about 200, was reached:

Number of sea-otters killed on Copper island, 1872–1882.

Year.	Sea-otters.	Year.	Sea-otters.
1872	9	1879	*2
1873	14	1880	128
1874	54	1881	190
1875	48	1882	200
1876	33		
1877	68	Total	840
1878	94		

*Thrown out by the sea. There was evidently no hunt that year. Dybowski (Wysp Komand., p. 64), upon the "authority of the overseer at Copper Island," gives 20 for 1879.

The arctic blue fox is common on both islands, most of the animals now found there being of the costlier dark phase, only a few white ones occurring occasionally on Bering Island. These are killed regardless of place or season, to keep the strain as pure as possible. The Copper Island fox skins are of a better quality, being larger and darker. The capture of the foxes is subject to as stringent and efficient regulations as that of the sea-otter. The island is divided into a number of well-defined districts (19 in Bering Island) for fox-hunting purposes, in each of which there is a hut (*yurt*, or *odinotska*) for the hunters. All the males between 18 and 60 years take part in the hunt, which ordinarily begins on November 10 (old style) on Bering Island, and November 20 (old style) on Copper Island, closing December 31. In each district a certain number of men, forming a gang, are detailed. Each gang hunts in common, and the proceeds of the hunt are divided according to shares, or each man to take his own foxes, as each gang may decide. As the various districts are more or less productive, a certain rotation is established so that each man has his chance at the best places as his turn arrives. Care, however, is taken that the old men are located in the more comfortable places.

The following table shows that the number of foxes decreases greatly when they are hunted for several successive years. The hunt is therefore suspended for one or two seasons, with intervals according to circumstances, in order to give the animals time to recuperate. The importance of the hunt is also shown, and the relative scarcity of the white phase.

Number of foxes killed on Bering and Copper islands, 1871–1883

Bering Island.			Copper Island.	
Season.	Blue foxes.	White foxes.	Season.	Foxes.
1871–72	836	4	1872	190
1872–73	580	28	1873	457
1873–74	514	24	1874	447
1874–75	.....	.....	1875	.....
1875–76	1,087	50	1876	696
1876–77	573	19	1877	.....
1877–78	.....	.....	1878	.....
1878–79	789	.....	1879	601
1879–80	.....	.....	1880	503
1880–81	.....	.....	1881	.....
1881–82	1,447	20	1882	1,033
1882–83	872	13		
Total	6,698	158	Total	3,927

The blue foxes must now be taken in traps exclusively. Shooting them is entirely forbidden, and as the foxes mostly live near the coast it is also forbidden to travel with dog sledges and to fire any shot near the coast after September 1 (old style). It was found that by digging them out of their holes females were mostly obtained, and this method has consequently been prohibited. The dried skins are sold to the company at a fixed price. As the natives are now paid 14 rubles for each first-class fox skin and 7 rubles for each second-elass skin, it will be seen that the foxes are a valuable source of income to them.

Owing to the ease with which the natives could procure seal meat for food, they have paid but little attention to other means of subsistence, particularly as the ready money obtained from the eompany for skins and work secured sufficient variation from the company's stores, whence they also obtain their flour, hard bread, tea, sugar, etc., not to forget canned provisions. As a result, the sea fishery does not yield what it otherwise might. On Copper Island, however, the natives catch some cod and halibut. They have a tolerably good boat harbor and many boats. On Bering Island however, the lack of a sheltered harbor and landing-place is a great drawback. On the other hand, the rivers and creeks of Bering Island are filled with salmon during the summer months, thus yielding the natives an abundant supply of fish for themselves and their dogs. The Saranna River is particularly important in this respect, The salmon are here caught in a substantial weir built aeross the river at the village of Saranna. During each summer nearly all the women are kept busy cleaning and drying from 60,000 to 100,000 salmon (pls. 60, 61). The weir is kept open from Saturday night to Monday morning to allow fish to ascend the river and lake to spawn. The bulk of the salmon put up belongs to the two species "Krasnaya riba," or redfish (*Oncorhynchus nerka*), and kisutch, or silver salmon (*O. kisutch*).

There is very little game now to hunt on the islands. The natives are very fond of the meat of the various sea birds, especially early in spring, and being provided with modern breech-loading guns and an unlimited supply of ammunition,[1] the result is that birds have beeome comparatively searce—very mueh so, in fact—near the villages. Ptarmigans (*Lagopus ridgwayi*) are, I believe, still numerous on Bering Island.

During their lease Hutchinson, Kohl, Philippeus & Co. introduced a herd of Kamehatka cattle on Bering Island and kept it at an expense entirely disproportionate to the benefits derived. The company has given up keeping cows, but the eattle have passed into the hands of the natives, while the white families on the island also have a few head to keep them supplied with milk. It has been supposed that eattle-raising might have a future on Bering Island, but past experience disproves the prediction, at least with the present breed of eattle. It has even been suggested "that these sturdy cattle might be advantageously introduced into the Aleutian Archipelago," but aside from the fact that it requires a good deal of care and fodder to bring them sueeessfully through the winter, even on Bering Island, the breed is highly objeetionable from the fact that the cows refuse milk the moment their calves are taken away from them.

On the other hand, I firmly believe that with a suitable breed sheep-raising eould be made a suecess, not only on the Commander Islands, but on the American Aleutian Islands as well. The climate is not more severe nor more moist than on some of the

[1] Mr. Kluge says the natives on Copper Island annually use 800 to 900 pounds of gunpowder.

Scotch islands, or the Faeroes, where sheep-raising and fishing are the main industries. But, of course, if an experiment is to be made, it must not be undertaken with sheep from California or some other country with a climate differing widely from that of the islands. It is imperatively necessary that a race like the Scotch black-face be employed; otherwise, the experiment would be sure to be a failure; but with proper precautions, and under the guidance of experienced men, I feel convinced that sheep-raising would be the proper solution of the food question in the Aleutian Islands.

On Bering Island the sledge-dogs would be an insurmountable obstacle to the introduction of sheep. As a matter of fact, however, the dogs are now of but little use, and should be exterminated—the sooner the better. The increasing number of boats have made the dogs superfluous along the coasts and for inland transportation, particularly from the main village, Nikolski, to the North Rookery. The introduction of a few Kamchatkan ponies would do the work much more satisfactorily, as proven by the success of the mules on the Pribylof Islands. In the fall of 1882 a couple of horses were brought over from Petropaulski, let loose, and allowed to take care of themselves during the entire winter, which was a rather severe one. The winter gales swept the level places nearly bare of snow and the horses found more than plentiful food in the dry grass thus exposed. So far from suffering hunger, the horses in spring were found to be slick and well fed; in fact, in better condition than when they arrived on the island. They were afterwards sold to a native, but died later, a circumstance undoubtedly due to the ignorance or lack of care of the owner.

The sledge-dogs are still one of the most interesting features of Bering Island. There must be at least 600 dogs in Nikolski, but while formerly they were allowed to run loose, and afterwards kept chained outside of the owner's house, Mr. Grebnitski has of late years banished all the dog-pens to the sand-hills back of the village, much to the improvement of good order and comfort in the village. Each dog has a hole in the ground large enough for him to lie down in while chained to a stout pole near by. Here they pass their days howling or sleeping, when not out traveling. For traveling a number of them, mostly 11 or 13, are hitched in pairs to a low sledge. A trained leader is tied on in front. This is an intelligent and valuable animal, and is guided entirely by the driver's voice. In winter, on the snow, such a team will haul a load weighing 400 pounds, and I have traveled 40 miles in a day, though without any baggage worth mentioning. But they are also used in summer on the bare ground. Of course, the rocky places are avoided as much as possible, and the summer tracks are preferably located over the marshes and in the low places. On frequented routes, as between Nikolski and North Rookery, or Saranna, the constant travel has worn deep ruts in the ground—in some places 2 to 3 feet deep. These ruts being veritable ditches, drain the surroundings, and are, therefore, usually in a very slippery condition, to which the droppings of the dogs add materially, making it fast if not pleasant traveling. Some of these routes are shown by dotted lines on the map of Bering Island (plate 4).

Most of the dogs differ greatly from the Kamchatkan dogs, belonging, in fact, to an entirely different race. They have large, hanging ears, and were originally brought to the island from Okhotsk. Of late years teams of Kamchatkan dogs, which have erect, pointed ears, and are very much like the ordinary Eskimo dogs, have been imported, as the original hang-eared dogs were degenerating from inbreeding, and now mongrels of all possible shades and with ears of all possible shapes are common

enough. The hang-ear dogs are furthermore distinguished by having the regular dog bark, while the Kamchatkan dogs can only howl.

The recent introduction of reindeer into Bering Island seems to have been a success. Hutchinson, Kohl, Philippeus & Co., in 1882, by the efforts of Dr. B. Dybowski, secured 4 male and 11 female reindeer in Kamchatka, which were safely landed on Bering Island July 15. During the following winter 2 females were killed by natives, but the herd increased by the birth of 6 or 7 calves. The reindeer took up pastures in the southern, mountainous part of the island, and are said to have multiplied rapidly. I did not see them in 1895, but I heard estimates of their number varying between 600 and 1,000 deer. A careful selection of bucks for killing would add to the fresh-meat supply, and at the same time promote the rapid increase of the herd.

It is not improbable that the reindeer might do well on Copper Island, in spite of the smaller size of the island, but I am inclined to the belief that the introduction of a *suitable, hardy race of goats* would be a better investment.

A few hens and tame ducks are kept in the villages on both islands.

A glance at the meteorological tables, pages 13–17, will show that any agriculture, in the proper sense of the word, is out of the question. On Bering Island there is a half-hearted, half-successful attempt at raising a few vegetables. Formerly most of the native families had "gardens" at Staraya Gavan, where turnips and potatoes were raised with varying success. The place was entirely too far from the main village, however, and new gardens have been started at Fedoskia, on the west coast, a few miles south of Nikolski. In 1895 there was only one man who still had a vegetable patch at Staraya Gavan. I believe that this industry could be made more successful if the natives were taught proper methods. One common error now committed is that all the vegetables are planted entirely too close together. It would also be necessary to look out for hardy plant seeds and seed potatoes raised in a northern climate.

The *fuel* used by the natives consists of coal and birch wood, the latter brought from Kamchatka and sold by the company, and of driftwood collected by the natives along the beaches. The latter article is very uncertain and is now often very scarce, though formerly abundant enough. Coal, on account of the long transportation, is expensive, and, like the birch wood, requires cash to purchase it. A couple of shiploads of the latter are required every year, and while the supply in Kamchatka is almost limitless at the present time, yet it is not so accessible now at places where there are people to cut it and where it can be loaded into a vessel. With the decreasing number of seals affecting the revenues both of the natives and of the company, the day does not seem distant when the former will be unable to buy, while the latter may find it unprofitable to have a steamer constantly plying between the islands and Kamchatka. Knowing, moreover, that the fuel question was a grave one on the other Aleutian Islands and that peat bogs may be expected to be found on many of the latter, as they occur on Bering Island, I undertook, in 1883, to investigate them and to bring samples of peat home for analysis. East of Nikolski, behind the sheltering hills and sand-dunes, a large swamp extends back to the foot of the three Saranna Baidar Mountains, covering several square miles. In suitable localities large beds of peat of excellent quality are found. On June 15, 1883, I had a couple of men cut about 350 pieces of peat from near the surface. The pieces, averaging about 2 by 16 by 8 inches, were spread out on a hillside to drain, and ten days later they

were stacked in pyramids in such a manner that the intervals between the pieces gave the air uninterrupted circulation between them.

When leaving the island in the autumn I found the pieces of good consistency and took a fair quantity with me to have the properties of the peat tested. They were turned over to Dr. Fred. P. Dewey, then curator of metallurgy at the United States National Museum, who kindly furnished me with a report of his analysis of the peat, which he found of good quality. It should be observed that the peat was from the surface, and therefore not nearly so good as it would have been if it had been taken deeper down. Dr. Dewey's report has never been printed, and, in view of the great importance of this question, both for Bering Island and the other Aleutian Islands, I think it well to submit it in full:

REPORT ON PEAT FROM BERING ISLAND.

As received, the sample consisted of about 30 slabs of the peat, most of them of considerable size, so that it can be considered as a fairly average sample; since, however, it had been collected several years, it was unusually dry. It was first tested by building a fire under a small boiler. It ignited with great ease and gave off its volatile matter at a low temperature, forming a good, solid flame without much smoke and giving off a good amount of heat. It required only a small amount of kindling wood to thoroughly start the fire, and after it was once started and had been thoroughly observed it was left to itself, and at the end of five hours it still had vitality enough to ignite fresh material, showing that it had good staying power. If there had been sufficient material on hand to build a large fire, it would probably have held its fire for 15 to 20 hours, but only a small fire could be built, and the result is very satisfactory. A small piece was cut off from each large piece and the small pieces properly ground and sampled for a chemical analysis, which yielded the following results:

Water	7.60
Volatile matter	51.97
Fixed carbon	22.06
Ash	18.37
	100.00

As might be expected from the time since the sample was collected, the analysis shows an unusually small amount of water, and while the ash is rather high, the whole analysis shows the peat to be above the average in its contents of actual combustible material, and that, therefore, it would undoubtedly form a very valuable fuel in the country where it is found.

As prepared for use by simply air-drying, peat frequently contains from 15 to 25 per cent of water, and unless artificial heat is used in drying it is not probable that this one could be dried to less than 20 to 25 per cent of water; and on this basis its composition would be—

Water	20.00	25.00
Volatile matter	45.00	42.19
Fixed carbon	19.10	17.90
Ash	15.90	14.91
	100.00	100.00

These results compare favorably with the following analysis of a peat from Devonshire, England, which has been used extensively for fuel:

Water	25.56
Volatile matter	35.41
Fixed carbon	29.30
Ash	9.73
	100.00

Should it be necessary to use artificial heat, it could, of course, readily be obtained by the combustion of a portion of the peat itself in a suitably designed furnace.

I am satisfied that this peat will make an excellent fuel, and that the proper steps should be taken to introduce its use among the natives of the region.

Most of the natives on both islands live in neat frame *houses*, built and presented to them by Hutchinson, Kohl, Philippeus & Co., instead of the damp and filthy sod-huts (here called *yurt*) which they formerly lived in. If properly located and built, however, the sod-house is well suited to the climate and the needs of the people, and the munificence of the above company ceasing with the expiration of the lease, the Zholti Mys natives, as well as many a new-wed young couple, have erected new sod-huts. These are built over a wooden frame, lined inside with boards, and the site properly drained (plates 15*b* and 16*a*).

Nowadays the males *dress* almost exclusively in imported ready-made clothes, and the women make themselves dresses of calico or woolen goods, though for heavy over-coats and capes they wear also imported ready-made articles. Even the latest fashions penetrate rapidly to these distant shores. My surprise may well be imagined at seeing girls there last year wearing gay-colored waists with enormous "leg-o'-mutton" sleeves! Ready-made shoes are also used in great quantities, for although a few men have been taught shoemaking, comparatively little repairing is done. The old home-made garments are going out of use. The old rain-coat, made of dried seal-guts, is being laid aside for the oil coat, and the native *tarbassi*—moccasins made of seal skin or the inside throat-lining of the old bull seals—are giving way to rubber boots. Even the baidarka, the graceful skin canoe, is a thing of the past, as the sea-lion has become nearly exterminated on the islands, and the same fate has befallen the large skin baidaras, great lighters made of a framework of wood over which was stretched sea-lion skins sewed together. The framework is taken apart and used for other purposes, and the steamers' boats do the work of the baidara.

The *municipal institutions* of the two Commander Island communities are particularly interesting, not only because they are peculiar, but because they differ so radically on the two islands. The system on Bering Island is one of nearly pure communism, while on Copper Island it may be termed individualistic by comparison. The local administration has of course a great power and influence, but the natives have also a great deal to say in regard to their own affairs. They elect for a certain term a chief and an assistant chief, subject to the approval of the administrator or local governor. The chief, in a measure, represents the community, and through him all communications to the natives have to go. This is particularly the case with reference to the company and its agents, who have absolutely no authority whatsoever over the natives, much less over the chief. The men attend to their internal affairs, receive the Government's communications, and hold their elections in their assembly house. The chief's business, among other things, is to see that the governor's orders are executed, that work to be undertaken is properly done, and that the moneys coming to the natives are properly distributed, etc. If I wanted a team of dogs and sledge I could not arrange with any native I pleased, but had to notify the chief, who would then send me the one whose turn, as duty or privilege, it would be to furnish the dogs.

A specified tariff for all work is provided. On Bering Island the total proceeds from the seal killing, 1.50 rubles per skin, is paid into the community fund and then distributed according to shares, each family, according to the individual rating of the members, receiving a certain number of shares and fraction of shares. For this the able-bodied men have to do the community work, including the sealing, without further compensation. On Copper Island an entirely different system prevails. There each family is paid for each skin which a member of the family brings to the salt-

house. Hence men, women, and children are engaged in the work, each family trying to bring in as many skins as possible. This system has been found necessary there, as the population would have been entirely inadequate to handle the catch if the Bering Island scheme had been adopted. It has resulted in overworking the Copper Islanders, expecially the females; but I am not certain that their more cheerful and independently open character, as contrasted with the more sulky and indifferent aspect of the Bering Island natives, is not due to the competition, on one hand, and the paralyzing communism on the other.

The *religion* of the natives is, of course, the orthodox Russian Greek-Catholic faith. They have built a fine and expensive church on each island. They also support a priest on each island, and on Bering Island an assistant priest or "diakon." The moral plane of the church—its methods, men, and members—is similar to that of the same institution in Alaska.

Schools are provided for both islands and housed in roomy and well-lighted buildings, very creditable in every respect. The children are provided with all the modern improvements in school furniture, as well as apparatus for object lessons, maps, and colored charts of animals and plants decorating the walls, on which, over the teacher's rostrum, also hang the portraits of the tsar and the tsarina. Whether the knowledge received by the boys and girls is up to the fine apparatus, I am not able to say. Anyway, the boys used to write a good hand, at least when the late Mr. Volokitin taught them. I also saw the apparatus of a modern school gymnasium, but as it was outside the schoolhouse and being painted dead-black, I surmise that the authorities had come to the conclusion that it was carrying coal to Newcastle to give the outdoor children of Aleut extraction the additional physical exercise of indoor gymnastics.

A *doctor*, appointed and paid by the Government, is now stationed on Bering Island, with a good drug store on each island. He has for an assistant a "feltcher" or barber, a native boy who has undergone a training at Vladivostok. The midwife, sent out from St. Petersburg by the authorities there, must also be regarded as the doctor's assistant.

A.—BERING ISLAND.

GENERAL DESCRIPTION.

Bering Island, the northwestern island of the Commander group, is situated between (approximately) 55° 22′ and 54° 42′ north latitude and 165° 40′ and 166° 41′ east longitude (pl. 4). Its greatest length from northwest to southeast is a little less than 50 miles, the average width being about 10 miles.

Two outlying islets, both not far from the northwestern extremity, properly belong here—*Toporkof Island*, a flat-topped, low island, about 2 miles west of the main village, and *Ari Kamen*, on older charts usually called Sivutchi Kamen, a higher basaltic rock, with a two-peaked top, 4½ miles farther west.

The southern two-thirds of Bering Island are exceedingly mountainous, with peaks rising to about 2,200 feet. The maximum elevation is nearer the western side than the eastern, and the rise from the sea consequently more abrupt along the former coast, the mountains sloping more gently toward the east. The valleys, as a rule, are shorter, narrower, and V-shaped on the west side, longer and more open on the other. The passes are usually high, 600 to 1,000 feet, but at one place, viz, between *Gladkovskaya* on the west coast and *Polavino* on the east, the two valleys

are continuous, with a very low watershed, thus dividing the mountains into two separate masses. In these the peaks, ridges, and intervening valleys are distributed without any apparent regular system. In the northern mountain mass, however, it is easy to recognize a dominating central stock between *Podutiosnaya* and *Buyan*, from which several of the largest streams of the island radiate west, north, and east, as, for instance, *Podutiosnaya*, *Fedoskia*, *Kamennaya*, *the Staraya Gavan* River, and the *Buyan* River. The most conspicuous mountain of the southern mass, and in fact the highest on the island, is the one which I have named Mount Steller.[1] It is located just south of the low valley between Gladkovskaya and Polavino, mentioned above, and is particularly impressive and beautiful viewed from the latter place. The mountains grow more forbidding and precipitous as the southern extremity of the island is approached, the last cape, a bold and knife-sharp promontory, the Stotchnoi Mys, better known as *Cape Manati*, being particularly picturesque.

The northern third of the island has an entirely different aspect from the remainder. In a general way it may be described as being low, the highest elevation being but slightly more than 600 feet. In reality it consists of a series of usually well-marked terraces. First comes the present beach followed by a steep coast escarpment averaging about 30 feet. In the deep bays this escarpment recedes inland so as to inclose the lakes formed by the rise of the land, and the heaping up by the sea of gravel and sand in front of them. Then follows a strip of varying width of nearly level or gently sloping land to the base of an intermediate, often abrupt, terrace, which brings us to an elevation of from 200 to 300 feet. The level following leads to the next and last rise, which is the highest, but also usually the most gentle, though in some places still quite precipitous. The level above this rise forms either large plateaus with a somewhat undulating surface, or the tops of singularly regular, flat-topped table mountains, which the natives, from their appearance suggesting overturned boats, have given the graphic name of Lotka, or Baidara, mountains. There are two groups of these table mountains, both very conspicuous when one approaches at sea the main village, viz the *Severnie Lotki*, two very regular and round tables, between 3 and 4 miles (nautical) north of Nikolski, and the *Saranskie Lotki*, three equally well-marked, though less regular mountains, about 5 miles distant to the northeast, on the west side of the great Saranna Lake. The highest altitude of the former group I have measured to be 577 feet; of the latter, 617 feet. The two main plateaus, which are situated north of the great lakes, are the *Northern Plateau* between Cape Zapadnie and Saranna, and *Tonkoi Plateau* from the latter place, where a deep cut, in which flows the Saranna River, separates the two plateaus, to East Tonkoi Mys, the *Cape Waxell* of many charts.

Between the terraced plateaus, which form the foothills and northern extension of the mountainous southern portion of the island, and the two detached table-lands named above, there is a depression extending across the island, which is filled by one very large and a number of smaller lakes, as well as by extensive swamps.

The large lake alluded to, *Saranna Lake*,[2] is quite an imposing sheet of water for so small an island, covering, as it does, an area of about 20 square miles. It connects with the sea at the Saranna village, on the north shore of the island, by means of a short river less than a mile long. The level of the lake is about 40 feet above that of the sea. From the western end of this lake there is almost continuous communi-

[1] Deutsche Geograph. Blætter, VIII, 1885, p. 240.
[2] On some maps called Fedoskia Lake, a name unknown on the island.

cation through a small swamp with two smaller lakes, which empty into the sea at the western side, through the *Ladiginskaya* River. A somewhat larger lake, the *Gavanskoye Ozero*, occupies the center of a large swamp immediately east of the main village. The stream by which it discharges its water passes the latter, and is Steller's Osernaya Reshka. The low land between the lake and sea is protected near the latter by several rows of high sand-dunes from the village to Ladiginsk.

It is a curious fact that Steller (Neuste Nord. Beytr., II, 1793, pp. 266–267) describes this lake as the largest on the island, and that he has entirely overlooked the existence of Saranna Lake. It is pretty good evidence that Steller did not visit that part of the island personally (unless possibly when it was covered with ice and snow) and explains also his omission of mentioning the great North seal rookery. There are a few small lakes, or rather ponds, in the southern mountainous portion, which need no special mention, except the one in *Lissonkovaya Bay*, as the natural conditions there are a miniature reproduction of the Gavanskoye Ozero. It may be added that Lissonkovaya is Steller's Yushin's Valley.

Bering Island has no sheltered harbors, and the few anchorages are indifferent or even dangerous under anything but the most favorable circumstances. The principal anchorage is in the corner off Nikolski, but with southerly or westerly winds it is not safe. It can be approached from the west by keeping close to the south shore of Toporkof Island, in order to avoid an outlying rock off the so-called Vkhodni Point, or Reef. The channel north of Ari Kamen and Toporkof is very dangerous and should be avoided. Farther south, on the same side, are two larger bays, Gladkovskaya and Lissonkovaya, but they are open and no landing can be effected in rough weather. On the east side is Staraya Gavan, the "Old Harbor," where there was formerly a settlement. The bay is small and narrow, with dangerous reefs on both sides.

These reefs are quite a feature of the Bering Island shores. In the northern portion they are mostly of volcanic nature, but in the mountainous portion they consist of stratified rock on edge in such a manner that many of them, especially at Tolstoi Mys and northward, when bare at low tide have the appearance of plowed fields with furrows of great length and regularity. On the stretch of coast just mentioned these reefs form a nearly continuous belt, one-fourth to one-half mile wide, and parallel to the beach. A narrow channel of somewhat deeper water, though only deep enough so that a large boat can be barely pulled and pushed through by low water, extends the whole length between the beach and the reef belt, which is covered by high tide. The continuity of the reef is only broken where some larger stream empties into a slight indenture of the coast, as, for instance, at Komandor, at Polavino, and at Buyan.

The main settlement is at *Nikolski*,[1] so named in honor of Mr. Nikolai Grebnitski, situated at the inner corner of the little bay east of Toporkof Island (pl. 17). The houses are built in several rows on the raised beach at the mouth of the Gavanskaya Reshka and partly upon the sandy slope of the adjacent hills, and being mostly frame structures are painted in many gay, if not always tasteful colors. Prominent also in this respect the new church, dedicated to St. Nicolas, raises its yellow dome over a grass-green roof, while the body is painted pink with white and sky-blue trimmings! The old church of St. Inakenti is still standing, dismantled and neglected.

[1] On some maps called Grebnitski Harbor, or Grebnitskoye Seleni.

At the western end of the village is located the new government building with offices for the administrator and the doctor, and next to it the new school-house, both rather large, but uninteresting, lead-colored structures (pl. 17*b*). In the center of the village is located the company's dwelling-house for the agent (pl. 18*a*), painted a friendly white and surrounded by the magazines, stores, stable, bath-house, etc. Beyond is the administrator's dwelling, unpretentious, but comfortable (pl. 18*b*). The sod-huts are relegated to the rear, and, hardly differing from the surrounding grass, are very inconspicuous (pl. 15*b*).

At *Saranna* (pl. 61) there is quite a village of small houses and huts for the women in summer, when they live there in order to put up the large salmon catch. A small frame chapel was being built last year on the brow of the hill back of the village.

The summer village at *Severnoye*, or the North Rookery, will be described under the head of the latter. There was formerly also a temporary village at Staraya Gavan, to accommodate the people during the planting and harvesting season, but a new one has been built in its stead at Fedoskia, not far from Nikolski.

SEAL ROOKERIES.

It was on Bering Island that Steller, in the spring of 1741, discovered for the first time the rookeries and breeding-grounds of the fur-seals, which he had previously observed traveling northeastward toward unknown regions. His classical descriptions, so well known to all naturalists, need not detain us here, except in so far as they relate to the extent and location of the rookeries. Unfortunately, his works contain very little bearing directly upon this question. In his "Beschreibung der Berings Insel" (Neuste Nord. Beyträge, II, 1793, p. 289) there are a few observations, however, which throw some light on the subject. On the 29th and 30th of April (new style) the shipwrecked crew had killed the first bulls just arrived. Steller at once concluded that they had found the breeding habitat of these animals and hoped for more to follow. He says:

> In this hope we were not deceived, for numberless herds soon followed, filling the entire coast to such an extent that one could not pass by without danger to life and limbs; nay, in some places where they covered the whole shore we were often obliged to travel over the hills and rocky places. * * * *These animals landed only on the southern side of the island,*[1] *opposite Kamchatka, consequently at least 18 wersts from the nearest place to our dwellings.* * * * [This was a long way to carry the big bulls, the flesh of which, moreover, was very unpalatable.] But we soon discovered that another smaller kind of fur-seal, grayish of color, which arrived with them in still greater numbers, had a much tenderer and more palatable meat, without odor, which consequently could be eaten without nausea. *We discovered also a nearer road to these directly south from our dwellings,* scarcely more than half as long as the former.

From these quotations it is perfectly plain that at the time of the discovery of Bering Island there were no breeding-grounds or rookeries on the east side of the island; that there were well-filled breeding-grounds on the west side; that these were situated on the shore where now are located the few hundred females forming the Poludionnoye, or South, Rookery, and that vast numbers of bachelors hauled up in Lissonkovaya Bay, where there are none now, nor have there been any apparently within the memory of the natives residing on the island.

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[1] Steller applies the term "south side" to the entire shore, which from our better knowledge of the topography of the island we would call the western shore. It is evident from various statements in his works that he did not visit the true northern shore between Cape Waksell and Zapadni Mys.

The destruction of this hauling-ground must be credited to the same parties who accomplished the extermination of the sea-cow in twenty-seven years.[1]

At the present day there are only two distinct rookeries on Bering Island, the principal one being located on the northern coast of the island, the other, a small affair, on the west coast.

THE NORTH ROOKERY. (Plate 7.)

The great North Rookery (*Severnoye lezhbishtche*) is situated on the northernmost prolongation of the island (Severni Mys; also called Cape Yushin) about 11 miles from the main village, Nikolski, and about 10 miles from the northwest cape, Zapadni Mys. The north plateau of the island recedes here from the sea, leaving a broad, level tundra, which slopes gently northward toward the sea, ending abruptly in a steep escarpment, about 30 feet high, between which and the water a flat beach, about 400 feet wide, extends all around the point.

From this beach a long, rocky reef, of volcanic origin, extends for half a mile nearly due north, ending in a somewhat isolated high rock, the so-called Sea-lion rock (*Sirutchi Kamen*). The terminal half of this reef is very low and, with the exception of the scattered larger rocks, under water at high tide; in fact, it requires very low water to be able to walk out to the Sea-lion rock. The basal half is formed by a slightly raised, long and narrow peninsula, about a quarter of a mile long by 400 feet wide, the central portion of which constitutes a hard, gravelly beach about 10 feet above mean tide, and gently sloping toward the water on both sides, and fringed, except at the base, by the rocky reef. The northern two-thirds of this gravelly central portion is covered with fragments of shells of mollusks and echinoderms, so that it appears quite white, for which reason this part of the rookery is often spoken of as "the sands"; the basal third is covered with a very rank growth of *Elymus mollis*, continuous with the fields of the same grass which line the inner portion of the beach up to the escarpment. The vegetation is now gradually extending in a wedge-shaped point northward over the central part of "the sands." Several isolated rocks surround the rookery on both sides, as well as numerous sunken reefs.

From the base of the projecting point thus described, which is specifically designated as the Reef Rookery (*Rifovoye lezhbishtche*), the coast trends east and is fringed with the same rocky reef as the rookery itself; but the seals do not haul up on these rocks, and they form no part of the rookery. The bay thus inclosed is comparatively shallow and sheltered, forming the principal playing-ground of the pups. Here they learn to swim. Near the south shore the rocks mark off a series of shallow lagoons.

From the western side of the "Reef Rookery," the base of which is here marked off by a detached rock, called *Babin*, or Babinski Kamen, the coast trends south-southeast. The beach shows the same characteristics, viz, an inner grass-covered belt, followed by a narrow, pebbly belt more or less whitened by broken shells and fringed by an outer rocky reef, which by low water embraces innumerable very shallow lagoons.

The grassy belt is widest (fully 400 feet) toward the reef, and the escarpment is here nearly obliterated by a little creek coming from the south. Its mouth is usually dammed up by the pebbles and gravel thrown up by the sea, and the grassy belt in this locality is therefore intersected by numerous connected pools of nearly stagnant water.

[1] L. Stejneger, How the Great Northern Sea Cow (*Rytina*) Became Exterminated. American Naturalist, XXI, December, 1887, pp. 1047–1054.

Farther south the escarpment again assumes its precipitous aspect and approaches nearer to the beach.

About five-eighths of a mile from the base of the "reef" the rocky beach projects again a little and, as the coast line beyond takes a more southerly turn, a corner is formed which the natives designate as *Blizhni Mys.* Just before this "cape" there is an expansion of the gravelly part of the beach which, like "the sands" of the reef, serve the seal hauling up in this neighborhood as a "parade" ground. This portion of the beach is now called *Kishotchnaya.* The patch of breeding seals located here are known as *Kishotchnoye lezhbistche* or (rarely) *Blizhnoye lezhbistche.*

Beyond Blizhni Mys the reef fringe, as well as the grassy belt, again expands, the escarpment retreating from the coast, only to reapproach farther south at another promonotory which is well marked by two high, grass-covered, mound-like masses of rock, the so-called Great *Maroshishnik*, or Maroshnik, and Little Maroshnik. Beyond this point the coast forms another slight bay, fringed with reefs, like the foregoing, but not so wide. This is *Kisikof*, and as this is the last point where seals are known to have hauled up *regularly*, it may be regarded as the southern end of the great North Rookery.

The *killing-grounds* are located on the gentle slope (about 3 in 100) above the escarpment, about 600 feet southeast of the base of the reef. The ground is here smooth and covered with a short, fine grass. The upper end is pitted all over with holes dug 4 to 6 feet deep and about 6 feet wide, used by the natives as "silos," into which they place the seal meat, intestines, etc., destined for winter food for the sledge-dogs. In addition, boxes and barrels are likewise scattered over that part of the ground, and in these the natives salt the seal meat for their own use (pl. 19*a*).

The *driveways* on this rookery are short and easy. From the reef the drive is scarcely three-eighths of a mile long, for the least part over the rocky beach, and for the greater portion through the shallow lagoon at the base of the reef and across the fields of rank grass. The ascent up the escarpment is scarcely 30 feet high, with an incline of about 35°. The road there is worn perfectly bare of vegetation and in wet weather is somewhat slippery, but not enough so as to cause a serious impediment to the drive.

The driveway from the southern end of the rookery is considerably longer, from Kishotchnaya, for instance, nearly three-fourths of a mile; but as it is partly over the same beach upon which the seals themselves haul up and travel about with ease, and partly over the inner grassy belt of the beach, no special hardship is involved. The killing-grounds are reached from the west side, where the escarpment is locally interrupted, and the gentle slope beyond extends down to the water.

The company's *salt-house* is located 500 feet north of the killing-grounds, at the extreme north end of the escarpment, and its reddish-brown walls and roof are visible all around for a considerable distance, being, in fact, the best landmark on this part of the island. It is a frame building, originally 45 by 26 feet, with a later eastern addition 20 by 24 feet. On the north side a plank "chute" and stairs lead down the escarpment to the beach below (pl. 24).

Southeast of the killing-grounds, about 1,200 feet from the beach, and between 60 and 70 feet above the sea, the mud-hut *village* of the natives, where the men live during the killing season, is located, and directly in front, north of the new huts, the only wooden dwellings of the place, one belonging to the Russian Government, in which the kossak and his family reside, the other (16 by 20 feet) built by the company

for its employees. Formerly the company's "sealer" lived in a small frame-hut just east of the salt-house, but this is now used for storing salt in sacks, while the kossak occupied a mud-hut, or yurt, a little farther east (pl. 25*b*).

There has of late years been several distinct yurt or mud-house villages at this rookery. The first one was situated just back of the coast escarpment, west of the salt-house, and between it and the present driveway, scarcely more than an eighth of a mile from the rookery. This was inhabited until 1877. In 1878 Mr. Grebnitski ordered the village to be moved back and the new yurts were built an eighth of a mile southeast of and farther up on the hill than the former. The yurts, or barabras, were low and small and dark, musty and dirty, and have recently become entirely unfit for use. A series of new ones have now been erected and others are still being built immediately east of the former site, and these are in every way supplied with "modern improvements," inasmuch as they are comparatively large, dry, and provided with windows. They are built entirely above ground, and constructed of uprights rammed into the ground and covered on the inside with boards nailed on lengthwise. The walls and roof are then covered with a thick layer of sod (pl. 16*a*). On the whole, they are rather comfortable and warm, being certainly more suited to the climate and the wants of the people than the ordinary frame-houses.

The appended map of this rookery (pl. 7) is the result of a traverse plane table survey made July 9 to 19, 1895, in the intervals between the rain and fog. A base line, exactly one-fourth of a statute mile long, was carefully measured off on the level ground to the west of the salt-house. About 100 angles, from 14 stations, were measured. Another map of the same rookery was made by me in 1882–83, but on a considerably smaller scale, by means of an azimuth compass and pediometer. The new and more detailed survey confirmed the accuracy of the old map. There has never been published any map of this rookery.

THE SOUTH ROOKERY.

The South Rookery of Bering Island (*Poludionnoye lezhbishtche*) is now a very insignificant affair. As mentioned above, it is the only remnant of the countless numbers of seals which Steller saw on this side of the island. Situated at 55° 57′ north latitude, on the west coast of the island, halfway between Northwest Cape and Cape Manati and nearly 16 miles in a straight line from the village Nikolski, it occupies a narrow, curved beach under the steep bluffs of the coast escarpment, which here rises perpendicularly from 60 to 100 feet high. A beautiful waterfall in the next bight to the east forms a very conspicuous landmark (pl. 32*b*), and three-fourths of a mile to the westward is one of the most perfect natural arches, which I have named Steller's Arch (pl. 27*b*).

The *rookery beach* is hemmed in both at the west end and the east by projecting spurs of the escarpment, and at the corresponding corners long rocky reefs run out into the sea, inclosing and protecting a shallow bay which, in spite of the openness of the coast, forms a safe harbor for the pups. The beach itself, hardly 100 feet wide, consists of an outer pebbly and rocky portion with a rather steep incline toward the water and an inner narrow and level belt covered with very tall vegetation, mostly *Elymus* and *Heracleum*.

The breeding seals occupy part of the pebbly beach, also hauling up on the outlying rocks of the reef.

The *driving* is made along the beach toward the east, and although not long, the entire distance being about 2,000 feet, is somewhat harder than on the North Rookery, as the seals have to be driven mostly over sand and round loose stones. The ascent to the *killing-grounds* is steep and high, about 50 feet, leading from the boat-landing up past the house, where the few natives live, and the small *salt-house* beyond (pl. 32*a*).

The accompanying map of the South Rookery (pl. 9), as the title indicates, is but little more than a sketch map. The time I had at my disposal was very limited, and did not suffice for a very accurate survey, or to measure off a reliable base line. The photographs I secured, however, testify amply to the general correctness of the map, and it is confidently asserted that the relative distances and angles are sufficiently accurate for all practical purposes. It is the first map published of this rookery.

B.—COPPER ISLAND.

GENERAL DESCRIPTION.

Copper Island (*Ostrof Miedni*), so called from the native copper, of which small quantities have been found from time to time near its northwestern extremity, lies between 54° 53′ 30″ and 54° 33′ 30″ north latitude and 167° 28′ 30″ and 168° 9′ east longitude (approximately). It is very mountainous, long and narrow, the length being nearly exactly 30 miles, the average width about 2 miles. The general trend is northwest to southeast, like that of Bering Island, from which it is distant only about 29 miles.

The northwestern extremity is formed by a projecting cape, continued in two characteristic and bold, detached rocks, the Sea Otter Rocks, *Bobrovi Kameni*. From this point to the southeast end, which is marked by several smaller conical rocks, the island consists of a backbone of peaked mountains from 1,000 to 2,000 feet high and connected by ridges varying from 500 to 900 feet high. Only in two places is this backbone broken, viz, near the northern end, where the Bobrovi Valley, between Pestshanaya Bay on the east side and Bobrovaya Bay on the west shore, cuts deep down to about 350 feet above the sea, so that Copper Island seen from a distance—for instance, from the opposite shore of Bering Island—looks like two distinct islands. The other place is near the south end. A very narrow and low neck only 900 feet wide and 75 feet high, very properly named *Peresheyek*, or isthmus, separates the mountains of the south end from the rest of the island.

The highest mountain on the island is *Preobrazhenskaya Sopka*, which rises precipitously above the main village. I have measured it with an aneroid twice, the height being 1,925 feet.[1]

Narrow, deep valleys cut into the sides of the island vertically to its axis. A kettle-shaped end with steep walls usually terminates these valleys, whence originate small creeks or rivulets which occupy the narrow bottom. The sides of the valleys are often quite smooth, the detritus consisting of small, sharp-edged pebbles, often forming long, unbroken slopes with angles from 30 to 40 degrees. The ridges between the valleys, if high, are usually very sharp and narrow.

The shores are mostly high and precipitous. Narrow beaches, covered with large bowlders of rocks fallen down from the cliffs behind, extend with many interruptions around the island, but the latter are so numerous as to make traveling along the beach for any distance impracticable. Cliffs and pinnacles, formed into most fantastic

[1] July 23, 1883, 1,921 feet; July 30, 1895, 1,929 feet.

shapes by the action of the waves, rise out of the sea all around the island, sometimes singly, sometimes in clusters. Occasionally large detached or half-detached rocks form more conspicuous landmarks, as, for instance, the Bobrovi Kameni mentioned above, the *Sivutchi Kamen* at the northern entrance to Bobrovaya Bay, and the one of the same name on the other side only a short distance east from the main village, the *Cape Matveya*, *Gladkovski Kamen*, both on the east side, and, most striking of all, perhaps, *Karabelni Stolp* at the rookery.

Outlying concealed rocks are few, except at the northwestern and southeastern capes, where dangerous reefs extend some distance into the sea. Otherwise the water around the island is bold, the farthest rock, to my knowledge, being off *Lebiazhi Mys*, is less than a mile from shore.

The rivers or brooks are necessarily all short and insignificant, hardly any one of them deserving special notice. A few of them, near their mouths, empty into small lakes, which have undoubtedly been formed by the sea throwing up material, thus damming off the inner end of the bay. Such lakes are *Pestshanoye*, just west of the main village; the lake at the end of *Zhirovaya Bukhta*, to the east of it; and *Gladkovskoye Ozero*, in the next valley beyond. The latter is not properly a lake, as the water is strongly brackish, the sea going in at high tide. There are many waterfalls, but on account of the insignificance of the streams, they are of little effect. A few, however, are quite picturesque; for instance, the one at Karabelni Rookery, figured on plate 45.

The entire western coast is very steep, with but few shallow indentations. On the eastern side the valleys are wider and deeper, and open into more or less deeply cut bays, none of which, however, offer sheltered anchorage for vessels much larger than a boat, and as the waves of the Pacific Ocean roll unchecked against the rocks and beaches, landing is often difficult or impossible even at the villages. Only the little rounded cove forming the harbor at the main village is an exception, it being well protected in almost all weather by a cluster of rocks off the entrance. But even this place is not always safe, as demonstrated by the fact that a tide-gauge, solidly built of timber in the most sheltered part of the cove and loaded with rocks, was thrown high on the beach by the surf during the winter of 1882–83.

The main village, called *Preobrazhenskoye*, or the "village of the Transfiguration," because of its church being thus consecrated (pl. 33), is situated on the eastern, or here more appropriately northern, side near the northwestern extremity of the island. Its neat, red-painted frame-houses and the handsome Greek church nestle cosily at the foot of a steep, high mountain, and it looks as if it might be a sheltered and pleasant place, but as a matter of fact it is not. The peculiar shape of the narrow valley at the mouth of which it is located compresses the winds and sends them howling down or up the cleft, while the precipitous walls, nearly 2,000 feet high on the east and south, shut out what little sunshine the island can boast.

Here the natives live all the year round, except during the sealing season, when the village is almost deserted. The company has here its stores and dwelling-house for the resident agent. The government has a large building (the office and dwelling of the assistant administrator), a drug-store, and a large school-house. The house in which the priest and his family live lies farther off, and is not distinguishable from the larger houses of some of the natives. The new church, which was built in 1895, at a cost of $9,000, is quite an attractive building, though entirely too large for the community.

The two "summer" villages in which the natives spend the few months of the sealing season are located on the east side, opposite the corresponding rookeries. The first one from the main village is *Karabelni*, openly situated among the low sand-dunes (pl. 34*a*). All the houses of the natives are small and poorly built huts, many of them being yurts or mud-huts. The salt-house and the government's house are the most imposing structures. Occasionally some of the families stay here until Christmas, or even the whole winter, but the Aleuts are too social a people to stand for any length of time such isolation for the sake of thrift or economy. The southern village is *Glinka*, picturesquely built on the slope of the steep coast escarpment (pls. 34*b* and 35); otherwise its general features are like those of Karabelni.

SEAL ROOKERIES.

The character of the Copper Island seal rookeries, owing to the precipitous nature of its coast and the narrowness of its beaches,[1] is very different from those on Bering Island. There is one quite notable similarity, however, viz, that none are situated on the eastern shore of the islands in spite of the fact that this side offers plenty of reefy and rocky places which might apparently answer all requirements. There are no records, to my knowledge, which would indicate that seals ever hauled up on the eastern beaches, and there is no reason to believe that they did.

There are two distinct rookeries on the west side of Copper Island, or, possibly we should say, groups of rookeries. However, while at the present day the various hauling or breeding grounds of each group are distinct and separate enough, they are manifestly only sections of the larger assemblage and are therefore most naturally and conveniently treated as such. These two main rookeries, named Karabelni and Glinka, corresponding to the summer villages of the same name situated opposite, on the east shore, are located in the southeastern half of the island, about 4½ miles apart.

KARABELNOYE ROOKERY.

The northernmost of the two main rookeries is Karabelni (*Karabelnoye lezhbishtche*) located south of the village of like name and easily recognized by a very characteristic isolated rock, *Karabelni Stolp*, which rises a hundred feet perpendicularly out of the water at the western extremity of the rookery (pl. 38).

The "Stolp" is connected with the main beach by a low, flat, gravelly neck, the western portion of which is rocky and covered with water-worn bowlders.

The main coast itself is formed by a series of nearly perpendicular bluffs, the rocky sides of which rise above a narrow beach from 200 to 300 feet, and the only way to observe this rookery is from some exposed points on the top of these bluffs. From their projecting angles, in most cases, long rocky reefs run out into the sea, between which small coves with a narrow gravelly beach offer shelter for the breeding seals and their young. The bays thus included commence at a projecting bluff, between which and the sea there is no passage by high water, situated just west of the "Stolp," the first one between these two points being called *Martishina Bukhta*. Next, on the east

[1] So steep are the rocky walls behind the Copper Island rookeries and so close do the seals lie to them that falling masses of earth and rocks have occasionally caused the death of many of the animals. Thus it is recorded (Otchet Ross. Amerik. Komp. za 1849, p. 23) that on the 16th of October, 1849, during an earthquake, a rocky wall fell down burying a rookery on Copper Island. Another earth-slide on one of the Glinka rookeries in 1893 similarly resulted in the killing of many seals.

side of the "Stolp," comes *Bolshaya Bukhta*, as the name indicates, the largest of these bays, followed by three small ones, viz, *Staritchkovaya*, *Dalnaya*, and *Nerpitcha*. In Bolshaya Bukhta the hauling-ground is mostly coarse gravel with water-worn stones, up to the size of a fist, strewn over the surface and here and there with large bowlders which have fallen down from the overhanging cliffs. The grounds of the bays to the eastward, on the other hand, are stony reefs of the stratified rock of which Copper Island is mainly built up.

Nerpitcha Bukhta is easily recognized by a graceful waterfall, which overleaps the bluff in a fall more than 200 feet high. It must not be confounded with another waterfall, yet to be described, which forms the characteristic feature of the hauling-ground specifically named Vodopad.

Beyond Nerpitcha the bluffs again rise so abruptly as to allow no passage along the beach beneath them; hence the name of this projecting bluff—*Nepropusk*. Between this point and the next a long rocky reef represents the beach; but the bluffs become gradually lower toward the middle, where a little creek has cut a V-shaped valley and falls over the comparatively low escarpment in a beautiful cascade 65 feet high (pl. 45). From this waterfall the part of the beach between these points is named *Vodopad* and the cape terminating it to the east *Vodopadski Mys*.

This Vodopadski Cape, with its outlying rocks, is the extreme southern point on this part of the coast. It is the promontory seen farthest to the southeast from all points of the coast to the north of it and farthest to the northwest from all points south of it, although it projects but very slightly beyond a line through the westernmost of these points.

From Vodopadski Mys the coast trends a little northward again, being similar in character—viz, a narrow reefy and rocky beach at the foot of the steep bluffs. It is followed by a slight indentation, from which the ascent is so steep and difficult that it has received the name *Krephaya Pad* (the hard valley). It is followed farther east by another *Nepropusk*. Beyond this, a narrow strip of beach is called *Malinka Bukhta*, the "bay" being chiefly due to the projecting reefs at both ends. It is the last beach upon which seals have *regularly* hauled up at Karabelni, and is called the "little bay," in contradistinction to the large bay immediately to the east, which is often called Bolshaya Bukhta instead of *Serodka*—a practice to be discouraged, as it gives rise to confusion with the hauling-ground adjoining the Stolp.

A glance at the accompanying map (pl. 11) and the photographs of this rookery (pls. 38 to 40) will show how exceedingly difficult the taking of the skins must be. The bachelors are chiefly driven from the hauling-grounds at Karabelni Stolp, Vodopad, and formerly Krepkaya Pad and Malinka Bukhta.

From the Stolp the seals are driven northward along the beach of Martishina Bukhta beyond the promontory, which can only be passed by low water, on to the beach of the rather wide and gently curving *Stolboraya Bukhta*. If the number of seals is so insignificant that the skins can be easily carried on the back and the meat is not wanted in Karabelni village, then they are driven across the little rivulet which here runs into the sea and are killed on the beach just west of it. The carcasses are left at the water's edge for the waves to carry off.

The *driveway* to Karabelni over the mountains is a long and very hard one, being fully 2½ miles long.

In order to facilitate the ascent up the coast escarpment a *stairway* has been built

of driftwood logs resting on pegs driven into the ground, as shown in the accompanying photograph (pl. 49*b*). The upper end of these stairs (68 feet above the sea) enters the little creek mentioned above and the driveway proceeds up the narrow valley. The kettle-shaped upper end of the valley, the sides of which form a slope of about 40 degrees, is separated from a similar kettle on the north side by a narrow saddle. This pass I have determined to be 643 feet.[1] The descent is steep, but not so high as on the south side, and the driveway now follows the bed of the little creek, as the narrow V-shaped valley affords no other road. The lower end of the drive, after it enters the grass-covered sandy plain back of the Karabelni village, where the killing-grounds are situated, is comparatively easy.

The *salt-house* was formerly situated at the front of the village, east of the river and of the large rock in the bay called *Urili Kamen*. The beach there is not very safe or convenient for loading the skins into the boats or landing the salt, for which reason a new one has been built at *Popofski*, the small "bay" just west of Urili Kamen (pl. 63*a*).

From Vodopad the driveway, if it is deemed necessary to take the meat to the village, is longer by at least a mile over the high plateau northeast of the rookery, besides being very severe in other respects. The grassy slopes of the valley opening at this point are very slippery and steep (about 30°), but the greatest hardship is caused by the exceedingly difficult ascent of the bluff before reaching the valley. The bluff here consists of the naked hard rock, and consequently steps built of driftwood logs, as at Stolbovaya Bukhta, were out of the question. They had to be roughly cut out of the rock itself, as shown in the accompanying photograph (pl. 45), which will give a better idea of this extraordinary place than any description. It will be seen that the side next to the picturesque waterfall is nearly perpendicular, in fact so steep that the men can not follow the drive up on that side in order to urge the seals on and to prevent them from going down over the precipice. To remedy this a rope is stretched from the top down to the beach, as is plainly shown in the photograph to the right of the fall. When seals are driven, rags and scraps of paper are fastened to this rope, which is kept in constant motion so as to frighten them and urge them on.

It is hardly to be wondered at that the men prefer to let the seals carry their own skins up this road. The top of these stairs is 65 feet above the sea, and I found it pretty hard work to climb it without carrying anything.

At Krepkaya Pad and at Malinka Bukhta there is no possibility of getting the seals up alive; hence they were killed back from the beach and their skins carried across the mountains. At Krepkaya Pad the men alone did the killing and carrying, while Malinka Bukhta was reserved for the women, who did all the skinning and carried the skins to the salt-house. Malinka Bukhta is reached along the beach from Serodka, but between it and Krepkaya Pad there is a *Nepropusk* which can not be passed.

The appended map of Karabelnoye rookery (pl. 9), was made in 1883, July 3 to 10. The angles were taken with an azimuth compass and the distance measured with pediometer. In 1895 my stay at the rookery was too short to make an independent plane-table survey, but a blue-print of the old sketch was placed on the table and a few necessary corrections made. A series of photographs taken at the time have also been used in verifying it.

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[1] Average of 6 observations on July 3 to 8, 1883.

GLINKA ROOKERIES.

The southern, or Glinka, group of rookeries (*Glinkovskoye lezhbishtche*) is situated about $4\frac{1}{2}$ miles southeast of Karabelnoye. They contain the most important hauling-grounds on the island, but at the same time the most inaccessible. The island is here very narrow, yet the mountains average even a greater height than farther north, and the passes between the short and steep valleys on the east and west sides are also very high. The mountains rise precipitously from the sea, bordered only by a very narrow beach of rocks and stones, hardly deserving the name. All the rocks are here stratified, with a very pronounced dip. The projecting capes run out into jagged reefs formed by the exposed broken strata standing nearly on end, while numerous outlying rocks and stones guard the approaches (pl. 47). Singularly formed rocks and pinnacles carved out by the never-ceasing breakers, and saw-tooth promontories mark the ends of the various bays.

The length of the whole beach of this rookery is about 6 miles, but this stretch is not occupied by a continuous line of seals. On the contrary, they are gathered in groups at certain points which, for some reason unknown to us, are preferred to others, although apparently equally suitable. These various seal-grounds are named as follows from west to east: Gorelaya, Lebiazhi Mys, Peresheyek, Urili Kamen, Pestshanoye, Pestshani Mys, Pagani, Zapadni, Sabatcha Dira, Palata, Zapalata, Sikatchinskaya, Gavarushkaya, and Babinskaya Pad.

Of these, Palata (*Palatinskoye lezhbishtche*) is unquestionably the most important. It is named from the high and sharp promontory which extends farthest out into the sea on this part of the coast, and which somewhat resembles a large house with a steep, peaked roof. The top of it is fully 500 feet above the sea, and the walls are very steep, being in fact nearly perpendicular on the south side. This is *Palata* proper. A very jagged reef extends in a southwesterly direction from the foot of it, and to the northwest are several detached rocks. From one of these, two of the accompanying photographs were taken (pls. 48 and 49). On the north side this promontory is separated from the high mountain walls back of it by a narrow gully, which toward the sea expands into a somewhat open basin, the bottom and sides of which are lined with a pale-buff clay. The beach, a narrow strip covered with large rounded pebbles, extends northward under the clayey banks for several hundred yards, and continues in the same manner under the precipices of one of the higher mountains of this part of the island, rising to 1,400 feet. No particular feature, except a pile of rocks somewhat larger than usual, distinguishes this part of the beach, which is named *Sabatcha Dira*, the "dog-hole."[1]

From here to Pestshani Mys the character of the coast and beach is the same, except that about halfway the overhanging cliffs crowd the beach still more closely, with a small reef at their feet, thus forming a "mys," or cape, *Zapadni Mys*, probably so called because it is situated nearly due west from Glinka village. The gently curving beach between Zapadni and Pestshani Mys is called *Pagani*, the Unclean, for no obvious reason. At this place there is a break in the mountain wall behind, for above the coast escarpment a comparatively wide valley opens up, the drainage from which empties out at Pagani in three distinct streams.

[1] There are a number of places on Copper Island called Sabatcha Dira, but they are in all other cases actual holes through the rocks. I have been unable to see the application of the name to that part of the Palata rookery now so designated. Formerly there may have been such a perforated rock, now crumbled to pieces.

The accompanying photographs (pls. 46, 54*a*) show the character of this beach better than any description.

Pagani terminates at the northern end with *Pestshani Mys.* This is an exceedingly jagged cape of the saw-tooth type, the strata of the rock being nearly vertical and with an outlying detached rock, preventing further passage along the beach. The name, meaning Sandy Cape, has no reference to any characteristic feature of it, but is due to the fact that it forms the eastern termination of *Pestshanaya Bukhta*,[1] Sandy Bay, which extends from this cape northwestward. The western termination of this bay is marked by a slight projection of the beach and a low stony reef, which forms the great *Pestshani hauling-ground.* A comparatively large stream empties into the bay at its inner end, draining a grass-clad valley of considerable size compared with most other valleys in this part of the island, and the coast escarpment is unusually low.

Beyond this hauling-ground the cliffs again approach the sea, and the slightly curved narrow beach, covered with water-worn stones and loose rocks, turns outward in order to pass a slight but very jagged projection of the cliffs, in front of which a low isolated rock on the beach and another in the water beyond the low reef form another attraction for the seals. The rock on the beach, called *Urili Kamen*,[2] Shag Rock, gives this part of the rookery its name (pl. 54*b*).

The beach from here to the next cape is narrow and rough, covered with water-worn loose rocks from the foot of the steep slope at the back into the sea. This cape terminates in a large, semi-detached, roof-shaped, grass-clad rock, which obstructs the passage along the beach. A low but knife-sharp ridge connects it with the cliffs behind; hence the name of the place *Peresheyek*, or Isthmus, and that of the rock *Peresheyekski Kamen.*

From this point the last cape seen to the west is *Lebiazhi Mys*, which is easily recognized by a pair of cone-shaped twin rocks rising from the extreme end of the reef and several single ones of similar shape nearer the cape, as well as by two detached dangerous rocks situated seaward in the direction of the reef, the outer one fully a third of a mile from the cape. The bay between Peresheyek and this cape is called *Lebiazhaya Bukhta*, Swan Bay; hence the name of the cape. The beach is rocky and stony.

On the other side of Lebiazhi Mys the coast trends more northerly and is visible all the way to Vodopadski Mys, Karabelnoye Rookery. But we are here only concerned with the bay immediately behind Lebiazhi, as it is the last seal-ground at this end of the rookery. The character of the beach differs not from the seal-ground preceding it. Its name is *Gorelaya Bukhta.*

Returning to Palata we notice that from the extreme point of Palatinski Mys the coast trends more easterly. The abrupt walls of the cliffs are even more precipitous, and the beach, utterly inaccessible from the land side, is fringed by wide reefs surmounted by tall isolated rocks assuming the most fantastic shapes as pillars, pinnacles, towers, etc. Projecting corners hem in snug little coves for the breeding seals, while the outlying rocks and reefs break the force of the angry ocean and afford shelter in quiet pools for the growing pups.

[1] There are at least four different Pestshanaya Bukhta on Copper Island, a source of great confusion.

[2] Urili Kamen is a common name for various isolated rocks on Copper Island; for instance, at the West Cape of Glinka Bay and in the bay off Karabelni village.

The first of these coves, as the name *Zapalata* (behind Palata) indicates, is situated immediately under the perpendicular southern wall of Palata itself, and guarded on the east side by the pillar-shaped *Stolbi.* The beach itself is narrow, but smoothly covered with small stones rounded and polished by the water and of a very light pearl-gray color. This is, possibly, the most important of the breeding grounds, and is accordingly named by Colonel Voloshinof "Glavnoye-Glinkovskoye Lezhbishtche" (Glinka Main Rookery). The name Zapalata, employed by the natives, however, is much preferable, not only because in common use, but also on account of its brevity and euphony (pls. 55, 56).

Sikatchinskaya follows on the other side of the "Stolbi" (pl. 57*b*), possessing the same main characteristics as Zapalata, merging eastward into *Gavarushkaya Bukhta.*

The end of the latter, or rather the beginning of the next bay, is marked off by a solitary, conical rock rising up in the middle of the reef. It is called *Babin*, and hence the name of the beach beyond, *Babinskaya Bukhta*, and the valley opening at this place several hundred feet above the beach, Babinskaya Pad. The beach is covered with the same water-polished, light-gray stones. This bay at its eastern end is blocked by a very rocky and rough reef, for which the natives only have an Aleut name, *Kulomakh.* This is the eastern end of the Glinka seal rookeries.

The main *killing-grounds* at this rookery are situated on the eastern side of the island, where the village and the salt-houses are located. Only of late years, when many drives have been so small that there were people (men, women, and children) enough to carry the skins on their backs across the mountains, and the meat was not wanted in the village for food, has it been the custom to kill the seals on the west side.

I have already remarked that the hauling-grounds east of Palata are utterly inaccessible from the land side. Formerly, when seals were plentiful, the bachelors used to haul up in great numbers on some of these beaches, notably at Babinski, and if the company's steamer, *Aleksander II*, happened to be at the island at a time when the weather and the waves on the west side of the island allowed boats to land there it was customary for the steamer to take the people around the Southeast Cape and land them at those hauling-grounds. The seals were slaughtered and skinned on the beach, while the pelts were taken on board the steamer and salted in the hull.

On the photograph representing Palata Rookery (pl. 50) a small patch of numerous white dots will be observed on the grass-clad hills near the extreme right of the picture. These white dots are sea gulls feasting on the carcasses of a small drive of seals killed here. It will be seen that this drive was neither long nor could it have been particularly severe. Not so the regular driveway from this rookery to the killing-grounds at Glinka village, a distance of nearly 2 miles over a ridge more than 1,200 feet high. The slopes to be climbed, or slid down, are in places 35° to 40°. They are partly grass-clad, and then very slippery.

From Zapadni and Sabatchi Dira the driveway is somewhat shorter and the pass over the mountain lower, *only* 760 feet, but the ascent is exceeding rough. The lower part follows the bottom of a narrow V-shaped valley—or rather gully—the bed of a short torrent filled with large bowlders, over which the seals have to struggle hard (pl. 58*a*). Higher up the slope becomes steeper and at the same time covered with a tenacious clay, hence very slippery. Steps have been cut in the ground to facilitate the ascent, but the clayey soil is soon smoothed down and made as slippery as before.

From Pagani the distance is about the same and the pass to be sealed but slightly higher (780 feet), but the ascent is not quite so steep nor nearly so rough, and the drive from this hauling-ground may be characterized as the least severe at this end of the island.

The seals hauling up west of Pestshani Mys used to have the longest of all the driveways on the island and one of the most severe as well. After being driven along the beach for some distance they entered the Pestshani Valley, where the river has cut down the coast embankment, and then had to climb the first ridge on the east side. If the drive was a large one—and in former days drives of 4,000 seals were not rare[1]—it took too long a time to ascend only in one place, so that one portion was driven over the ridge where it was only about 670 feet high, while the other had to climb at least 900 feet up. On the other side of this ridge was a descent into Pagani Valley, then another hill was ascended, and finally a third ridge, 780 feet above the sea, had to be climbed before the final descent into the Glinka Valley took place. The length of this drive was about $2\frac{1}{2}$ miles, and in warm weather it sometimes took two days to finish it.

This was finally found to be too great a waste of time and energy, and as more salt-house room was required it was decided to drive the seals the shortest way across the island, and as there was a good anchorage and a tolerably decent beach for landing boats, to build a new salt-house there. This is now known as the *Pestshani salt-house* (pl. 58*c*).

This change has shortened the drive from the rookeries west of Pestshani Mys from $2\frac{1}{2}$ miles to $1\frac{1}{2}$. In addition, there is now only one pass to climb, which my aneroid showed to be about 740 feet above the sea. The ascent is not very steep nor is the road particularly rough, but the final descent to the salt-house is simply a "slide." On the whole, it is now the easiest of the long drives at Glinka. This, of course, does not mean that the drive is an easy one, and only a fraction of all the seals driven (in 1895 about one-sixth) gets the benefit from it.

The killing-grounds are located on the grassy slope near the beach, just north of the Pestshani salt-house. The killing-grounds at the Glinka village used to be beyond the houses, but are now moved to near the beach a few hundred yards north of the village. In the latter there are two *salt-houses* close together. One of these has had an addition built to it, so that it is now twice its original capacity (pls. 35, 36).

The map of the Glinka rookeries (pl. 13) is the result of a traverse plane table survey made during the few intervals from August 4 to 11, 1895, in which the rookeries were free from fog or rain. It was very difficult to find a level locality long enough for a suitable base line. After the map was completed, however, I measured off a line 1,000 feet long on the beach in front of the village and sighted it in on the map.

I had with me a sketch map which I had drawn from sketches and angles obtained in 1883. It was found fairly accurate, especially considering the fact that the fog during my visit in 1883 was so perverse that I never obtained a simultaneous sight of both sides of the island.

[1] In 1887 as many as 6,000 seals were taken in one drive at this place, according to Dr. Slunin.

2.—ROBBEN ISLAND.

DESCRIPTION.

Robben[1] Island, a literal translation of its Russian name, *Tiuleni Ostrof*, is situated in the Okhotsk Sea, 11 miles southwest from Cape Patience (*Mys Terpenia*), the end of the curiously long and narrow peninsula on the eastern shore of Sakhalin Island. The position is variously given as 48° 32′ north latitude and 144° 45′ east longitude, or 48° 35′ north latitude and 144° 44′ east longitude (recent Russian charts, while on the manuscript chart of the late Capt. J. Sandman I find given as "corrected longitude," 144° 30′ east).

Not having had an opportunity to visit the island myself, the following description is taken from a number of available sources. The accompanying maps (pl. 6) are copied from recent plans issued by the Russian hydrographic office in 1889.

The island is really hardly more than a large, flat-topped rock, trending northeast by southwest, long and narrow. The entire length of the reefy beach in that direction is about 2,100 feet, while the elevated portion, which rises abruptly to between 40 and 50 feet and tapers off to a point at both ends, measures only 1,400 feet in length. The width of this portion hardly exceeds 150 feet, while the reef surrounding it varies between 50 and 150 feet.[2] On the west side, near the southwestern end, there is a lower place, with somewhat sloping sides, upon which the company's salt-house and the barracks for the Aleut workmen and the naval guard are located. A rocky reef extends to the northwest, terminated by a large rock, the *Sivutchi Kamen*, about 10 feet high, a favorite resort of the sea-lions.

There is no harbor or convenient anchorage, and in bad weather vessels have to seek shelter under Sakhalin. Captain Sandman's manuscript map indicates "anchorage anywhere to northwest of island in from 10 to 20 fathoms; 13 fathoms, sandy bottom, 1 mile off, center of island SE. ½ E.; end of South Reef S. by E. ½ E.; end of North Reef and rock ENE. Nearer in rocky bottom."

There is no water on the island.

The climate is naturally more "continental" in its character than on either the Commander Islands or Pribylof Islands, having colder winters and warmer summers, but I am not aware that any regular observations have been published for the island. Mr. C. Carpmael, director of the Meteorological Service of Canada, has furnished a few figures, but they are apparently only based upon curves in the *Challenger* Report and are mere approximations. He states (Fur Seal Arb., VIII, p. 511) that according to these the mean temperature for May would be about 42 degrees, but thinks possibly the mean might be as low as 40 degrees. In June it is "probably about 48 degrees." In July "probably a little under 60 degrees." In August "it must be nearly 60 degrees." In September "it must be a little below 55 degrees." In October "about 44 degrees."[3]

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[1] Not Robbin Island, or Robin Island, as it is occasionally written.

[2] These figures are taken from Shamof's map (pl. 6). Lieutenant Egerman, I. R. N., gives the following dimensions: Length 1,960 feet; width about 300 feet; height 48 feet (Morskoi Sbornik, 1884, No. 11, Lots. Zam., p. 8). Capt. J. G. Blair says "1,960 feet long, by 175 feet wide, and in places 46 feet high" (Fur Seal Arb., III, p. 194).

[3] According to Shamof (Ausland, 1885, p. 537) the mean temperature at Cape Patience, Sakhalin, was 52.2° F. for June, and 62.4° F. for July, 1884.

The mean temperature of the surface of the water around Robben Island is given by Makarof as 13 degrees centigrade (middle of August).

These temperatures are considerably higher than the corresponding ones at the Commander Islands, and lend color to the statements by Captain Blair and Capt. G. Niebaum, that the Robben Island seals can be distinguished by experts from those on the Commander Islands, and that they do not mingle with them, being a separate and distinct herd (Fur Seal Arb., III, pp. 193, 204).

Very little is known about the movements of the Robben Island seals, except that they migrate southward. I am informed by Capt. D. Grœnberg, however, that sealers who are said to have followed up the migrating herd assert that these seals come up the Gulf of Tartary and pass through La Perouse Strait into the Sea of Okhotsk. The feeding-grounds of the Robben Island seals seem to be unknown.

The knowledge of the condition of the rookery is also highly fragmentary. When the first sealers arrived there they found the whole beach surrounding the island so occupied by seals that there was no place to effect a landing without driving the seals off. At present the few remaining seals congregate on the very narrow beach on the southeast side of the island.[1] The bachelors are now hauling up on both sides of the breeding females, and so close that many females are caught in the drives.

The various estimates of the number of seals on this island may be somewhat more accurate than similar figures from the other seal islands, because of the small extent of Robben Reef and the ease with which the rookery can be watched. Thus, in 1871, when Hutchinson, Kohl, Philippeus & Co. took possession of the place, Mr. Kluge found that "there were not over 2,000 seals to be found on the entire island." Capt. G. Niebaum, who visited it at the same time as the representative of the firm, states as follows: "The rookeries were also very small, and contained at that time, of all classes, about 800 seals, as I ascertained by a careful count, and, in addition, a small number in the waters adjacent."[2]

In administrative respect Robben Island is under the jurisdiction of the administrator of the Commander Islands and is included in the lease of the latter. In fact, Robben Island is regarded as a dependency of Bering Island, as the men of the killing gang are taken from that island and the money for the Robben Island seals goes to the Bering Island natives. Since 1885 the government has stationed a force of 20 sailors and an officer of the navy on Robben Island, in order to protect it against

[1] The breeding-ground, according to Dr. Slunin (Promysl. Bog. Kam. Sakh. Komand., p. 12), occupies about 4–5 sazhen by 70–100 sazhen (a sazhen being equal to 7 feet).

[2] Dr. Slunin (Promysl. Bog. Kam. Sakh. Komand., p. 13) has been able to utilize certain reports by some of the naval officers in charge, from which a few interesting facts are noted: "According to the reports of Lieutenants Rosset (1887) and Brumer (1892) the arrival of the first bulls depends upon whether the ice has disappeared along southern Sakhalin or not; but whether there is any ice present in the Bay of Terpenia or at the mouth of the Taraika is apparently of no significance. Thus, in 1891, the bulls arrived very slowly; on June 5 (old style) there were in all 28 males, 65 females, and one pup; in 1892 the ice also remained late on northern Sakhalin, and on May 15 (old style) there was not one seal on the rookery, the first bull arriving on the 16th of May (old style). In 1893 the first bulls appeared on May 17 (old style) at the coast, although broken ice was lying along the eastern side; the temperature of the water was 2.5° C. Ice was covering the deep water of Terpenia Bay. * * * In 1891, at the end of the period of birth, there were on July 3 (old style) 5,000 females and 4,000 pups, showing one-fifth of the females to be virgin. Lieutenant Brumer notes the following special circumstance: In July and the beginning of August (old style) there were about 15,000 to 17,000 seals, but in September the inhabitants of the rookery had increased considerably."

Dr. Slunin himself, in the beginning of May (old style), 1892, calculated the number of seals on Tiuleni to be from 13,000 to 16,000 all told, allowing 3 square feet to each animal, large and small (*op. cit.*, p. 17). In 1892 the first bulls arrived about May 16 (old style), and the first females May 20 (*op cit.*, p.27). This is contrary to what he states on p. 18, where it is said that in 1892 the bulls arrived about June 15–18 (old style), and the females came ashore on June 26.

the raiders, but apparently with but poor success, judging from the history to be related further on. This failure is partly due to the fact that on account of the severity of the season the guard has been taken off before the middle of October.

As remarked above, the island is included in the lease of the Commander Islands, and Hutchinson, Kohl, Philippeus & Co. took possession of it in 1871. The Robben Island part of the business was attended to chiefly by the schooner *Leon*, Capt. John G. Blair; mate, Mr. E. Kluge. The name of the schooner belonging to the new company is the *Bobrik* (pl. 59*b*), Capt. D. Grœnberg, master, who for many years was first mate on the old company's steamer *Aleksander II* (pl. 59*a*). The skins have hitherto been shipped to London via San Francisco.

HISTORY OF ROBBEN ISLAND.

The history of this little reef is very interesting and highly instructive as showing how nearly impossible it is to extirpate the seals, either by harsh measures on shore or by excessive raids from marauding vessels.

The existence of seal rookeries on Robben Island was probably first discovered by some of the numerous American whalers frequenting Okhotsk Sea in the early fifties. In a recent statement Capt. G. Niebaum alludes to these early visits as follows:

> From information gathered from various sources I learn that Robben Bank was first visited and exploited by whalers about 1852 or 1853, and that in two seasons they obtained some 50,000 or 60,000 skins, almost completely "cleaning it out." I understand that for several years thereafter the occasional vessel which touched there found the rookeries practically deserted. (Fur Seal Arb., III, p. 203.)

Captain Scammon (Marine Mammalia, pp. 150–152) gives an account of a visit of a New London bark to Robben Island in 1854 or 1855, which it may be well to reproduce here:

> In the midst of the Crimean war an enterprising firm in New London, Conn., fitted out a clipper bark, which was officered and manned expressly for a sealing voyage in the Okhotsk Sea. The captain was a veteran in the business, and many thought him too old to command, but the result of the voyage proved him equal to the task. The vessel proceeded to Robben Island, a mere volcanic rock, situated on the eastern side of the large island of Saghalien. Many outlying rocks and reefs are about it, making it dangerous to approach and affording but slight shelter for an anchorage. Here the vessel (of about 300 tons) lay, with ground tackle of the weight for a craft of twice her size. Much of the time fresh winds prevailed, accompanied by the usual ugly ground-swell, and in consequence of her being long, low, and sharp the deck was at such times frequently flooded; nevertheless, she "rode out the whole season, though wet as a half-tide rock," and a valuable cargo of skins was procured, which brought an unusually high price in the European market on account of the regular Russian supply being cut off in consequence of the war.

Robben Island was thus "practically cleaned out"; the whaling industry also came to an end, and the very existence of seals on the lonely rock was almost forgotten.

At the breaking up of the great Russian-American Company in 1869, many enterprising citizens of California and Alaska turned their attention to the Pribylof Islands and the Commander group; the Kuril Islands and the Okhotsk Sea attracted the attention of Captain Limachevski. With a schooner manned by Aleuts (Kadiak Islanders?) from Urup Island, the station of the Russian-American Company on the Kuril Islands, he sailed, in 1869, to Robben Island. During the 14 years of rest since the Crimean war the seals had again multiplied to such an extent that they were occupying the entire beach all around the rock, as in the days when first discovered.

The Urup Aleuts, who had never had any experience with the driving of fur-seals, were afraid of the vast numbers which blocked the way, so that no landing was effected, and Limachevski had to sail away.

In 1870, however, the seals did not fare so well. In that year at least two schooners raided the island. Mr. D. Webster, of Pribylof Island fame, arrived there in the schooner *Mauna Loa*, and the number of skins taken on Robben Island was probably more than 20,000.[1]

The island was "practically cleaned out" again, so that when the representatives of the lessees of the Russian Seal Islands arrived on Tiuleni in 1871, "there were not over 2,000 seals to be found on the entire island." Capt. G. Niebaum, a member of the firm, landed there in August, and seeing the depleted state of the rookery ordered that no killing should take place there that year, nor, in fact, until "such time as seemed prudent to resume, so as to give the rookeries opportunity to recuperate, leaving strict orders to the guard-ship to protect them against molestation." The result of this wise order was that in 1873, not more than two years after, the rookeries had so far recovered that sealing could be commenced again on a small scale, and about 2,700 seals were taken that year by the company, "knowing that the killing of the useless male seals would accelerate the increase of the herd. From this time forward the herd showed a steady and healthy growth,"[2] and would probably have continued so had it not been for the unparalleled boldness of the seal pirates. They fitted out in Japan and sailed under various flags, British, German, Dutch, United States, etc., and from about 1879 paid special attention to searching for hitherto unknown seal rookeries on the Kuril Islands and elsewhere in the Okhotsk Sea, as well as raiding those already well known. Robben Island, being conveniently located, poorly protected by a single schooner and a few Aleuts, and absolutely unprotected later in the season, after the company had finished the legitimate catch, was particularly exposed to the ravages of these marauders. The total number of seals indiscriminately slaughtered by them on that lonely rock will never be known, nor, probably, the names of all the vessels that took part. The following few particulars, however, will give a good idea of the slaughter and the methods.

In 1880 the company's schooner *Leon*, Captain Blair, landed at Robben Island with the Aleut workmen on June 13 and found there already two schooners, the *Otsego* and the *North Star*, though they had been unable to do anything, as the seals had not yet arrived. During the summer schooners were scarce. On June 22 the *Vladimir* touched there; on July 16 the *Stella* came around, and on July 20 the *Flying Mist*. On September 4 the company's steamer *Aleksander II*, Captain Sandman, called and took off the 3,330 skins. Sandman records in his log that he found "on shore a considerable number of pups and females, but very few killing seals." After the lessees' vessel left, however, things became lively. When Capt. A. C. Folger arrived in the schooner *Adèle* he found 11 schooners already assembled there, and he states (Fur Seal Arb., VIII, p. 662) that "altogether we got 3,800 seals; we killed them all or drove them away." It is possibly to the raids of this year that W. F. Upson refers (*tom. cit.*,

[1] Webster, according to the British Bering Sea Commission, put the number of skins he assisted in taking at 15,000, but they add that "Kluge's estimate of the number taken was 10,000." When reading this report on Bering Island last summer, Mr. Kluge stated to me that he understood Webster's catch in 1870 to have been about 20,000, and that he did not "estimate" 10,000, as alleged by the commissioners, he not having been there at the time. (Rep. Brit. Bering Sea Comm., p. 89).

[2] Niebaum, Fur Seal Arb., III, p. 203.

p. 724) when he states that he "was on the first schooner that raided Robben Island, the *Matinée*, fitted out by H. Liebes, T. P. H. Whitelaw, and Isaac Leonard," of San Francisco.

In 1881 a number of schooners again hovered around the island, waiting for the guard-ship to leave, even as late as November. About the first of that month Mr. E. P. Miner arrived in the *Annie Cashman* and met three other schooners there. "We went ashore and clubbed the seals. Our schooner's share was 800 skins." (Fur Seal Arb., VIII, p. 701.) Those four schooners, therefore, probably secured about 3,200 skins.

This feature of the schooners raiding in concert is well worth noticing. Captain Folger corroborates it: "We worked together, and the schooners would divide up." The latter also mentions how the schooners succeeded in eluding the vigilance of the guard-ship and making raids during its absence:

> We had the guard [i.e., the Aleut workmen] in our pay, and when the *Leon*, which had been sent there to guard the place, would go away, lights would be put out, and we would come over from Cape Patience, where we had men on the lookout constantly, or if we got impatient the fastest sealer in the fleet would go there and be chased by the *Leon* (a sailing vessel), and the others would make the raid. (Fur Seal Arb., VIII, p. 663.)[1]

The experience of the authorities with the raiders in 1881 led to more vigorous attempts to protect the rookeries. The first step was the issue of the consular warning referred to in detail elsewhere in this report (chapter on Raids of Commander Island Rookeries, p. 120), and to enforce it a stronger force of natives was sent to the island in 1882. They were well armed and under the command of a non-commissioned kossak officer. The proclamation and the presence of patrolling men-of-war had evidently some restraining effect upon the pirates in so far as the Commander Islands were concerned, but the result was only that the raiders concentrated their efforts on Robben Island. At least 13 schooners hovered about that rock in 1882, and, emboldened by the previous success, they actually carried the island by armed force. As the greatest loss to the island usually was inflicted after the guard-ship had left in autumn, most of the raided seals being females and young ones of both sexes, it was determined that the guard should winter there, and the men consequently remained when the *Leon* sailed. Shortly after, 6 schooners anchored off the island and each landed 10 well-armed men. The Aleuts, thus outnumbered, did not dare resist, and were locked up in the house. The crews of the schooners then quite leisurely went about the clubbing of the seals. It is probably to this raid that E. P. Miner, schooner *Otome*, refers when stating that the raiders "landed and killed about 12,000 seals" (Fur Seal Arb., VIII, p. 701). The natives, being thoroughly intimidated and seeing the smoke of a steamer, took to their boat and made for it. It proved to be Philippeus's supply steamer *Kamchatka*, on its return trip along the Okhotsk coasts. The men were taken to Korsakovski, a port near the south end of Sakhalin, and wintered there.

This is the story of the kossak and natives. On the other hand, it has been asserted that they were bribed. So far as the result is concerned, it matters very little which story is the true one. The rookery was now becoming so depleted by illegal, reckless, and indiscriminate slaughter that it was seriously considered by the authori-

[1] So bold did the schooners become that when Lieutenant Shamof, of the cruiser *Razboinik*, in 1884 sent to guard Robben Island, landed near Cape Patience, Sakhalin, on May 21, he found there two sheds containing about 15,000 pounds of salt, etc., three skiffs, and a whaleboat, and six Japanese, the whole outfit belonging to a schooner from Japan, of which a certain Johnson was said to be the captain (Ausland, 1885, pp. 536–537).

ties whether it would not be the better policy to kill off the few remaining seals and to abandon the island. If the seals were not killed by the company they were taken by the raiders, extermination was sure to follow, and it was only a question who were going to have the skins, the legitimate lessees, who were paying for the privilege and acting under contract with the legal owner of the island, the Russian Government, or the pirating poachers, who knew well that they were doing lawless acts, and who, moreover, also knew that their penalty for the criminal business, if caught, would be confiscation and, possibly, hard work in the mines of Siberia. Under those circumstances it is hardly to be wondered at that the decision was to disregard the distinction between sex and age in the killing by the lessees, as it was done by the poachers. This was undoubtedly done in 1883, and it is quite possible that some of the men, when more seals had been clubbed than the little gang could properly skin, in their zeal may have slashed the skins to prevent the raiders who were continually hanging around, among them the schooners *North Star*, *Otome*, *Helene*, and *Adèle*, from profiting to the extent of even having the seals clubbed for their benefit. It is utterly unjustifiable to characterize the proceeding as "barbarous" in contradistinction to that of the poachers. The number of seals thus killed has been grossly exaggerated. Some of the poachers have estimated it to be from 12,000 to 20,000 seals, but it is pretty safe to say that there were not nearly so many seals at that time on the island, all told. The number mentioned by another of the poaching captains (Fur Seal Arb., VIII, p. 664), viz, 3,500, is undoubtedly much nearer the mark.

Notwithstanding all this, enough seals hauled up on Robben Island in 1884 to justify the lessees in continuing the regular killing that season. They were particularly encouraged to do so since the Government had stationed a man-of-war, the *Razboinik*, to guard the rookery. Four seizures were made, among them the German schooner *Helena*, Captain Golder, which had "raided that island five years." Others escaped, like the *Felix*, which got 500 skins (Fur Seal Arb., III, p. 358). The killing of other classes of seals by the company on shore, however, was brought to a stop by Col. Nicolai Voloshinof (since deceased), who visited the island that year on a tour of inspection.

The Government, seeing that energetic means had to be taken if the seals were to be protected at all on Robben Island, in 1885 stationed a regular naval force of 16 sailors of the Siberian flotilla and 1 officer on the island, which was removed, however, before the middle of October. The company that year obtained less than 2,000 skins, but the schooners, late in autumn, made additional hauls; thus the *Penelope*, Capt. E. P. Miner, on her part alone got "about 800 skins" (Fur Seal Arb., VIII, p. 702). Captain Blair, of the *Leon*, estimated the number of seals on the island that year to be about 6,000.

For four years, 1886 to 1889, inclusive, the company refrained from taking any skins on the island; but there were still some left for the raiders, who appear to have visited the rock every year. The British Bering Sea Commission states that "these schooners must have obtained at least 4,700 skins" (Rep., p. 89). In 1890, the last year of the lease of Hutchinson, Kohl, Philippeus & Co., 1,456 skins were secured by them.

With the lease of the islands by the Russian Seal Skin Company the regular killing was again resumed in 1891, but the poor result led to the abandonment of the attempt in 1892. In 1893 the rookery had recovered sufficiently to yield the company 1,500 skins; 1,000 were taken in 1894, and 1,300 in 1895.

In all these years the raiders continued to prey upon the island in the autumn,

with but scant danger of being captured. In October, 1891, however, Captain Brandt, commanding the *Aleut*, upon returning to the island unexpectedly, captured two schooners, the *Arctic* and the *Mystery*, both fitted out in Yokohama but flying the British flag and having 1,500 seal skins on board (Brit. Behring Sea Comm. Rep., p. 89).

The latest raid on Robben Island was undertaken last autumn. On October 29, 1895, the British schooner *Saipan*, sailing from Yokohama early in October, ostensibly on a shark-fishing expedition, landed 17 of her crew on Robben Island. She sailed away, promising to return in eight days. In the meantime the Russian transport *Yakut*, which did patrol duty around the Commander Islands during the summer, arrived and found the 17 men with a great number of slaughtered seals. They were arrested and brought to Vladivostok, where she arrived about November 6. The schooner returned to the island too late, and thus escaped capture.

In addition, there is no doubt that the Robben Island herd must have suffered somewhat from pelagic sealing proper, though the extent can not be known.

Capt. D. Grœnberg, of the *Bobrik*, in 1895 reported that females were present in fair numbers, and that the proportion of bulls to females was about 1 in 40. The weight of the skins taken was good, and yearlings were quite scarce. He also mentioned having observed an unusual number of dead pups.

Number of skins taken by the lessees of Robben Island from 1871 to 1895.

Year.	Seals.	Year.	Seals.
1871	0	1885	1,838
1872	0	1886	0
1873	2,694	1887	0
1874	2,414	1888	0
1875	3,127	1889	0
1876	1,528	1890	1,456
1877	2,949	1891	450
1878	3,140	1892	0
1879	4,002	1893	1,500
1880	3,330	1894	1,000
1881	4,207	1895	1,300
1882	4,106		
1883	2,049	Total	44,909
1884	3,819		

3.—OTHER ISLANDS.

Omitting all references to breeding rookeries on the mainland of Kamchatka as based upon hearsay, and in all probability resting on misidentification of young sea-lions, it may be well in the present work to mention those localities in the Okhotsk Sea, besides Robben Island, where seals are said to haul out to breed.

ST. IONA ISLAND.

This is a small island, about 2 miles in circumference, situated in 56° 25′ north latitude and 143° 16′ east longitude, 120 miles north of the northern extremity of Sakhalin Island and a little more than 150 miles east of Port Ayan. It is said to be about 12 feet high and to have a crowd of detached rocks lying off its west side.[1]

[1] "*St. Iona Island*, in lat. 56° 22½′ N., long. 143° 15¾′ E., is merely a bare rock, about 2 miles in circumference and 1,200 feet high, surrounded on all sides, except the west, by detached rocks, against which the waves beat with great violence, and which probably extend a considerable distance under water. With the island bearing north, distant 12 miles, Krusenstern had 15 fathoms water, but when it bore west, about 10 miles, no bottom could be obtained with 120 fathoms" (China Sea Directory, IV, 1884, p. 178).

William Hermann, a seal-hunter of San Francisco, states that in 1890 his schooner got 283 seals on the island of St. Iona; that, altogether, 700 seals were obtained there that year by three schooners, and that in 1891 he was there again, and got 551 seals in the schooner *Arctic:*

> These were got hauled up on the rocks, and were first discovered by Captain Pine, of the *Arctic*, in 1889. Eight years ago Captain Peterson, of the schooner *Diana*, of Yokohama, was there, and there were no seals there (Fur Seal Arb., VIII, p. 709).

This last paragraph does not necessarily mean that we have to do with newly formed rookeries on St. Iona. In the first place, it is not stated at what date the island was visited; in the second, the seals may have been easily overlooked. I will mention an instance to show this. In 1881 Capt. J. Sandman, in the *Aleksander II*, in passing the Kuril chain was looking for the possible existence of fur-seal rookeries on the uninhabited islands. His attention was particularly drawn to Sredni Island, quite a small and insignificant affair. He happened to approach it from the Pacific side, and seeing nothing but sea-lions went away. Imagine his chagrin when he heard that Mr. Snow landed on the island that same season, taking several thousand seals. They were located on the Okhotsk Sea side.

SHANTAR ISLANDS.

It has been supposed upon the "very categorical statement" of the captain of the *Walter L. Rich*, and of Captain Powers, that fur-seals occur at the Shantar Islands (a numerous group of large and small islands in the Shantar Bay, 55° north latitude and 138° east longitude), and it is quite possible that such is the case.[1] I am also told that seals have been taken on a small island close to the Okhotsk coast.

It is believed that both the company and the Russian Government possess more definite information about these various islands than has been given to the public, but that it has been withheld so as not to invite raids by sealing schooners. In the spring of 1895 the authorities in St. Petersburg granted the Russian Seal Skin Company the right to take seals on all the islands, known and unknown, upon the payment of a stipulated tax and upon condition that a Government officer accompany the vessel dispatched by the company.

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[1] "*Shantarski Islands* lie off the western coast of the Sea of Okhotsk, about 150 miles northwest of Cape Elizabeth on Saghalin island, and although the largest island (Great Shantar) is 35 miles long, east and west, and about the same distance broad, it does not appear to afford any port or shelter; though its southwest point projects to the S W., so as to form a bay on the south side of the island. Between this bay and the nearest point of the continent, 14 miles distant to the southwest, are two islets surrounded by rocks and reefs. Soundings of 30 to 40 fathoms over a bottom of stones will be found at 8 to 10 miles to the eastward of the group. The tides run from $1\frac{1}{2}$ to 2 knots an hour.

"To the southward of the south points of Great Shantar island are some small islands which have not been examined.

"*Fekshptoff Island*.—At 6 miles from the west side of Great Shantar is Fekshptoff Island, 20 miles in extent, NE. and SW., and 10 miles wide, but it has no port nor shelter" (China Sea Directory, IV, 1884, p. 178).

III.—SEAL LIFE ON THE COMMANDER ISLANDS.

HISTORICAL AND GENERAL.

The northern fur-seal (*Callotaria ursina*) was known to the natives of Kamchatka and the invading Russian promyshleniks long before the islands to which they resort to breed were discovered. The seals were seen to arrive in spring, on their way north and east, and to return in autumn, and the correct conclusion was formed that the seals went to some unknown coast to bring forth their young.

The discovery of Bering Island revealed this unknown coast. Steller, the naturalist of Bering's expedition, had a whole spring season on the island in which to study their habits, and that he made good use of it is evidenced by the account he gave of these animals in his famous memoir, "De Bestiis Marinis," published in 1751 in St. Petersburg.[1] In this paper, written in the Latin language and finished on Bering Island for publication, he established the salient points in the natural history of the fur-seal. Two figures, one of a bull (fig. 1) and one of a female (fig. 2, pl. XV), probably made by the artist Berekhan, as shown by Dr. E. Büchner (Mém. Ac. Imp. Sc. St.-Pétersb. (7), XXXVIII, No. 7, pp. 12–13), accompany the descriptions. Fig. 2, at least, is a fairly characteristic representation of a bull, and superior to several figures published much later.

Steller described in some detail the external and internal anatomy of the fur-seal, or sea-bear, as he called it, and gives a pretty accurate account of their migrations and their habits on the island during the breeding season. He stated that they are polygamous, each bull having "8, 15 to 50 females"; describes the harems and the bravery of the bulls fighting for the possession of the females; the birth of the one pup shortly after the arrival of the mothers; the nursing and the play of the pups; the long fast of the bulls on the rookery, etc. In fact, he covered nearly all the essential features of their lives. Later researches have made but few corrections, and the additions have been those of detail and elaboration.

Such detail and elaboration was to some extent furnished by the venerable "apostle of the Aleuts," Ivan Veniaminof, who gathered his information on St. Paul Island, Pribylof group, more than eighty years later than Steller. A very precise and concise account, both of the natural history of the animal and of the sealing business, communicated by Veniaminof to Admiral von Wrangell, then chief manager of the Russian-American Company, was published in 1839 by the latter in the German language,[2] and was thus made easily accessible to the scientific world of his day. His somewhat more voluminous account in the Russian language did not appear until the following year.[3] He carefully distinguishes the various classes of seals—the *sikatchi*, or old bulls; the *polusikatchi*, or young bulls; the *holustiaki*, or bachelors; the *matki*, or mother seals; the *kotiki*, or pups, and the yearlings. The sikatchi in spring arrive first on St. Paul Island, about April 20 (old style; May 2 new style), "even if the

[1] Novi Comment. Acad. Sc. Imp. Petrop., II, pp. 289–398; pp. 331–359 relate entirely to the fur-seal.

[2] Statistische und Ethnographische Nachrichten über die Russischen Besitzungen an der Nordwestküste von Amerika. Gesammelt von dem ehemaligen Oberverwalter dieser Besitzungen, Contre-Admiral v. Wrangell. St. Petersburg, 1839, 8vo XXXVIII + 332 pp. and map; pp. 39–48 treat of the "Seebär. *Phoca ursina.*"

[3] Zapiski ob Ostrovakh Unalashkinskago Otdiela. St. Petersburg, 1840, 2 vols.

island is still beset by ice,"[1] and take up the same place as the previous year, being extremely fat upon their arrival. They pass most of the time sleeping, before the arrival of the females, when the sikatchi tries to get hold of as many as possible for his harem, in which he succeeds not without bloody contests with other males. "From 1 to 150 females have been observed with one sikatch, the number depending simply upon his bravery. He is the unrestricted lord, the guardian and protector of his harem. He takes no food whatever when staying ashore."

The polusikatchi and holustiaki arrive later and congregate in large companies upon the grounds which are usually separate and more distant from the sea than the breeding grounds. The females commence to arrive on May 26, rarely on May 21, shortly before giving birth to their single pup, the season for the delivery being from the end of May "through the whole of June, and even as late as July 10." The kotiki arrive usually by southerly winds, but not with the same regularity as the others, all not having arrived even by the middle of June, "as there are instances of yearlings having arrived as late as July." The sikatch comes together with the female some time after the birth of the pup, but only once; he "is able to cover from 21 to 25 females in 24 hours." The pups "feed exclusively upon the milk of their mothers until leaving the land. The female never suckles her young while in the water, but coming ashore for that purpose attends her offspring in a resting position." The pups do not go into the water until they are 30 to 35 days old, becoming familiar with the water when 40 to 50 days of age. "The color of the pups when born is black, but from September 10 changes to gray, the old hair being cast off." The seals leave the island (St. Paul) gradually, beginning about October 5, and always with north and northwest winds, the young ones remaining longest. A few old bulls may occasionally be seen in November, or even December, but none in January or February. "Very rarely 2 or 3 sikatchi show themselves again in March, but always for a very short time only."

I have thought it worth while to give the above short summary of the natural history as it was known in 1840, since it has been asserted that from the time of Steller to about 1870 "the scientific world actually knew nothing definite in regard to the life-history of this valuable animal." Not even the pictorial representation of the northern fur-seal in that period was so bad as it has been made to appear, as will be plain from an inspection of Choris's drawing of a fur-seal rookery on St. Paul, published in 1822 as pl. XV of his "Voyage pittoresque autour du Monde" (Fol. Paris, 1822) of which I append a greatly reduced copy on pl. 59.

Since Veniaminof's account, no original contributions to the natural history of the fur-seal, of any magnitude, appeared until the studies of Scammon, Bryant, and particularly Elliott were given to the public in the early seventies. These, with the

[1] The arrival of first bulls on Bering Island rookeries are reported for a few years as follows:

Date.	No. of bulls arrived.	Locality.
1879, May 5	2	North rookery.
1880, April 27	3	Do.
1881, May 20	2	South rookery.
1882, April 19	4	North rookery.
1883, May 23	2	South rookery.
1384, April 27	2	North rookery.
1895, May 10	1	Do.

On Copper Island the first bulls, 7 in number, were observed in 1895 on May 13.

bulky literature which sprang up as part of the "Fur Seal Arbitration" case, are too well known to need any further comment in this place.

The natural history of the Commander Islands seal is essentially that of the Pribylof Islands seal. Even their migrations, although along entirely different and distinct routes, show parallel phenomena. The route of the Commander Island herd, as we have seen, was known to Steller in a general way, but it is only recently, since the pelagic sealers are following the migrating herds, that the routes have become known in detail. Mr. C. H. Townsend, the naturalist of the United States Fish Commission steamer *Albatross*, has made a special study of this branch of the subject and has kindly furnished me with the following notes relating to the migrations of the Commander Islands herd as shown by the records of the pelagic sealers:

Pelagic sealing off the coast of Japan usually commences about the middle of March and lasts until the middle of June. The seal herd appears to be massed off the coast between the latitudes of Yokohama and Cape Noishap (the eastern point of Yezo Island) in March, April, and May. In March sealing commences off Hondo Island (Nipon); in latitude 36°, where seals are also of common occurrence in April, but they are then moving slowly northward. In May the best sealing is found south and east of Yezo Island, Cape Yerimo (the southeast point of Yezo) being a favorite sealing-ground. In June they are usually a little farther north, being taken generally off the eastern coast of Yezo and the most southerly of the Kurils. They are also taken in June off the more northerly Kurils, but the herd is then farther off shore and more scattered.

In the Japan region proper, sealing is carried on from the coast out to a distance of about 300 miles, while in February straggling seals have been taken as far south as the Bonin Islands. Seals occur in the Sea of Japan, catches having been made at several points there and in La Perouse Straits by the schooner *Penelope*, in a voyage around Yezo Island during the past season.

Sealers crossing the Pacific in the latitude of Yezo Island pick up seals at many points between Japan and the longitude of 180°. In June and July scattered bands of seals, presumably of the Commander Islands herd, occur 500 or 600 miles south of the western Aleutian Islands.

The charts accompanying my report on the fur-seal fishery for 1895 (Senate Document 137, part II, Fifty-fourth Congress) show the positions where seals were taken by 20 vessels sealing off the coasts of Japan and Russia during the past four years.

LATITUDE IN THE PHENOMENA OF SEAL LIFE.

It can be safely said that most of the points in the life-history of the fur-seal have been cleared up, in so far as they can be cleared up by direct observation, but the recent activity for information in this matter resulted also in a vast accumulation of misinformation gathered by and from persons either untrained in scientific methods, inexperienced in this particular subject, or prejudiced in favor of some pet theory, or biased by political considerations. This unnatural history of the fur-seal has caused doubts and confusion in the minds of those who have to trust to the literature for their information as to the truth of even some of the most easily observed and most firmly established facts. Renewed investigations have, therefore, become desirable.

Aside from the mass of downright misinformation, a good deal of harm has been done by the often too sweeping generalizations based upon a few isolated facts and caused by ignorance of the true relations of the latter as exceptions and not as rules.

It must not for one moment be imagined that the lines are as tightly drawn in nature as in many books and reports. It will probably be possible to cite more or less isolated occurrences contrary to nearly every habit of the seals as generally outlined. These exceptions are not frequent enough nor important enough to affect the general result, and it may be confidently asserted that the investigations which have of late been carried on by the American Bering Sea Commission and quite recently by the

United States Fish Commission have brought out correctly the main facts relating to the life-history of the seals.

We have frequently seen, however, that the various exceptions alluded to have been brought forward in the controversies relating to this theme as particularly essential, thus obscuring the main questions, while, on the other hand, conditions have been described and depicted as so uniform and stable that it has been easy for the opposite side to controvert these assertions, thus throwing doubt upon the correctness of the whole argument and the soundness of the conclusions. It may be useful, therefore, to review a few of these questions.

A protracted stay at the rookeries reveals two facts. The one which probably first impresses the observer is the curious stability of the general outline of the groups of breeding seals, especially if the comparisons be made at frequent intervals during the earlier part of the season. The masses of seals assume certain definite shapes which in many cases have no apparent relation to the nature of the ground upon which they are lying. Thus, on the North Reef Rookery on Bering Island, a very peculiar feature of the distribution of the breeding seals this summer was a narrow band of seals which extended obliquely across the northern end of the "parade-grounds," cutting off from the latter a small oval portion, visible in most of the photographs (plates 19, 21, 22) and also indicated in the map (plate 8), and connecting the masses of seals on the western side of the reef with those on the eastern side. I have walked over the territory thus curiously occupied many a time, but I have failed to find any difference in the ground which will account for this belt or answer the question why the seals do not also occupy the bare oval island it surrounds.

To appreciate this *general* stability of the outline, it is necessary to have had an opportunity to observe the rookery for some length of time. A person who had only a few days at his disposal for examining the same rookery might, on the other hand, be impressed by the fact that on two different days, or at different hours of the same day, the outlines thus referred to present entirely different aspects, and if he offered photographs in evidence of this fact he might seemingly prove the instability of these lines. Thus, the "band" of seals on the North Reef Rookery above alluded to did occasionally entirely disappear, particularly during the warmer portion of bright, sunny days, or after the rookery had been disturbed by a recent drive (see pl. 26).

Nevertheless, this "band" was a very *characteristic* feature of the seals on that rookery. Single photographs are therefore of no particular value for comparison *from year to year unless they are taken by a person familiar with the characteristic distribution and the view is selected by him for that particular purpose.* The main reliance must, therefore, be placed upon the observer, and his statements must be received in accordance with his known experience, accuracy, and intelligence.

PROPORTIONATE NUMBER OF SEXES AND AGES ON ROOKERIES.

A question which of late has been given considerable prominence is that of the relative number of breeding females and old bulls on the rookeries. Upon this, and upon the closely connected one as to the number of females a bull is able to serve, there has been a great diversity of opinion.[1] My experience this summer leads me to

[1] While maintaining that the value of the guesses as to the number of females a bull is able to serve is of necessity very dubious, I may mention that Mr. Kluge, who for eight years spent the summer upon Tiuleni Island with the seals practically under his very eyes the whole season, informed me this summer that "he does not for a moment believe that twenty-five females to a bull are in the least too many," though he did not venture to guess at the maximum.

the belief that, *on the whole*, a bull is able to take care of as many females as he can keep around him. There is undoubtedly great individual differences in this respect, some bulls being stronger than others, but I think it can be safely asserted, *as a rule*, that the procreative power of the bull is in direct proportion to his general physical strength. I think it also sound to assume that, *as a rule*, a bull physically strong enough to live through the winter gales and the vicissitudes of his winter wanderings and to return to his place on the rookery is also strong enough to fulfill his duty there. I have purposely emphasized "on the whole" and "as a rule," because I can easily imagine individual cases of, for instance, accidentally castrated bulls, or old feeble ones who might have the good fortune to meet with unusually favorable conditions during their winter migrations, etc., and because I am quite willing to admit that a number of such bulls may be found on each rookery. These exceptions, however, do not materially alter the above propositions as relating to the whole population of the rookery.

The train of reasoning which led me to the above conclusions is as follows: Some of the most noteworthy of my observations this summer on the Commander Islands establish the facts (1) that the decrease in the killable seals was most marked on Copper Island; (2) that there was a full complement of pups as compared with breeding females on both islands; (3) that there was an ample supply of bulls, old and young, on Copper Island, while on Bering Island they were much less numerous as compared with the number of females. I was informed that the latter condition was not peculiar to the present year (1895) alone, and it is also particularly mentioned in Mr. Grebnitski's report for 1893. It would therefore seem as if the different proportions between the sexes on the two islands have had no visible influence upon the number of pups born.

The soundness of the above deductions may receive corroboration, or the reverse, by observations on the South Rookery on Bering Island in 1896. On that rookery the disproportion between the two sexes was excessive in 1895. According to reliable information, the number of bulls on the whole rookery did not exceed five.[1] Judging from what I saw of this rookery during two visits, I should place the number of breeding females at about 600, possibly only 500. It would be a comparatively easy matter to observe this year whether the number of pups born be very markedly small in proportion to the number of females hauling out.

On the large rookeries it is difficult, if not impossible, for various reasons, to correctly estimate the average proportion between the bulls and the females, and particularly so on Bering Island, because the bachelors to so great an extent haul up between the breeding females. Mixed in among the latter in this way, it is next to impossible at long range to say, with any approach to accuracy, what the proportion between these two classes is.[2] In general, the difficulty lies in the fact that the individual harems differ so greatly in size. Thus, during the visit to Kishotchnaya Rookery, Bering Island, on July 9, Mr. Grebnitski counted several harems which contained all the way from 12 to 93 females, or more. But there is still another serious difficulty, which is due to the constant going and coming of the females, so that

[1] When I visited the rookery on August 17 the bulls had already left. It was rumored in the village that there had only been one bull, but Nikanor Grigorief, the native in charge of the killing there, informed me that the actual number was five.

[2] It is held by some that the natives have such a marvelously keen eye and discriminating power as to enable them, at least, to make such an estimate. At one time I accepted this as a matter of faith, but my experience last summer—to be detailed further on—has convinced me that the natives are not particularly gifted in that respect. As a matter of fact, their estimates are about as much guesswork as that of the white people, only that from their greater familiarity with the ground and the seals, they are apt to guess more closely.

the number of females in the individual harem fluctuates between 0 and the maximum, according to the time of day or condition of weather. Thus, on the 16th of July, on the same rookery, I counted a harem having 16 females, which, upon a recount a few hours later, contained 23, "while some of the other bulls were entirely deserted."[1]

I have above alluded to the difficulty of discriminating at a great distance between the females and the killable bachelors when mixed on the breeding-ground. The difficulty is not confined to these two classes alone. The experts profess to be able to separate the bachelors into yearlings, 2-year-olds, 3-year-olds, 4-year-olds, and 5-year-olds, and in the descriptions and discussions we find these classes mentioned in such a way as to lead to the impression that they are easily recognized on the rookery or the killing-ground, but nothing can be further from the facts. With hundreds of dead seals before me, I have been unable to draw any line between the various ages, nor has anybody present been able to point them out to me.

I have submitted elsewhere in this report a series of weights of skins (p. 109) which shows beyond a question that there is an unbroken series of all sizes from the smallest to the largest. The whole question resolves itself into a mental sorting of the killable seals into a number of classes, calling the smallest two-year-olds, the largest five-year-olds, and roughly distributing those in between among their respective classes. The yearlings, however, form a fairly well-marked class by themselves, as do, of course, the bulls—features not apparent in the tables of skin weights alluded to, from the fact that these classes are not killed.

The fact that even the natives are not always able to tell the females from the bachelors on the rookeries was curiously proven to me one day at Glinka, Copper Island, when Aleksander Zaikof and the chief, Sergei Sushkof, had a somewhat heated controversy over the question whether a certain body of seals on the Urili Kamen Rookery consisted of bachelors or females. Both of the men are among the most experienced and intelligent on the island. Yet it was only because Sushkof had been stationed the whole season at Glinka, while Zaikof only arrived with us the day previous, that he was regarded to be in the right.

But even at closer range it is sometimes difficult to distinguish the sexes. On the killing-ground, where the teeth of the seals are easily seen, there is, of course, no special difficulty, and mistakes are seldom made; not so in the drives, however.

During a small drive at Glinka, Copper Island, August 8, 1895, about 300 seals were made to cross the mountain pass (about 800 feet) in three main divisions, no less than 30 grown men taking part in the driving. Halfway up one of the men declared that there was a "matka" in the drive. It was questioned, but upon closer scrutiny he was found to be right. It was not until the final sorting before the killing took place that several females were discovered in the flock.

As an additional indication of the lack of definition of the different classes of seals as expressed in their sizes, I append a few tables of measurements taken from the freshly killed animals.

[1] The number of animals and the proportion of the sexes on North Rookery, Bering Island, during July, 1893, as quoted by Dr. Slunin (Promysl. Bog. Kam. Sakh. Komand., p. 9), from the official journal of the overseer (*offitsialni dnevnik nadziratelia*) are worse than useless. The numeration by the overseer in question is the worst kind of guesswork, if not entirely fictitious. Dr. Slunin's remark that the conclusions to be made from those figures would be strange (*stranni*) is certainly appropriate.

Measurements (in millimeters) of fur-seals (Callotaria ursina), Bering Island, North Rookery, July 30, 1882.

No.	Sex.	Total length.	Fore legs.	Hind legs.	Girth behind fore legs.	Nose to eye.	Nose to ear.	No.	Sex.	Total length.	Fore legs.	Hind legs	Girth behind fore legs.	Nose to eye.	Nose to ear.
1...	Male....	1780	495	555	910	105	212	12...	Male....	1250	360	400	780	82	165
2...	....do ...	1660	465	475	920	95	205	13...	....do ...	1205	325	410	775	82	175
3...	....do ...	1560	480	495	880	95	180	14...	....do ...	1200	292	380	700	75	165
4...	....do ...	1550	390	490	890	92	204	15...	....do ...	1185	300	385	750	68	152
5...	....do ...	1430	430	465	790	83	175	16...	....do ...	1180	330	415	810	85	180
6...	....do ...	1390	390	470	860	85	180	17...	....do ...	1170	345	400	750	83	166
7...	....do ...	1380	400	455	795	85	175	18...	....do ...	1140	315	395	700	75	165
8...	....do ...	1345	360	455	800	90	175	19...	....do ...	1125	350	385	730	85	184
9...	....do ...	1340	370	440	829	90	180	20...	....do ...	1100	300	355	710	75	168
10...	....do ...	1330	360	440	870	82	185	21...	....do ...	1035	255	340	620	73	155
11...	....do ...	1260	405	450	710	85	183								

Measurements (in millimeters) of specimens of fur-seals collected for United States National Museum at North Rookery, Bering Island, August 20, 1883.

	No. 2519 male.	No. 2520 male.	No. 2521 female.	No. 2522 male.	No. 2523 male.	No. 2524 male.	No. 2525 male.	No. 2526 female.	No. 2527 pup.	No. 2528 pup.	No. 2529 pup.
Total length	1495	1930	1283	1495	1475	1285	1085	1025	800	800	785
From nose to end of outstretched hind feet	2505	2450	1650	1935	1935	1655	1390	1255	1040	1030	965
From nose to armpit	1125	980	685	780	775	660	605	520	410	427	375
From nose to eye	110	98	67	78	90	80	72	60	55	59	52
From nose to ear	214	213	168	183	173	158	154	148	120	120	111
Distance between eyes	98	104	70	83	72	71	70	70	59	55	54
Distance between ears	183	173	138	150	140	138	120	125	99	104	98
Length of ear	52	52	45	53	53	47	39	46	38	42	32
Length of longest mustache bristle	195	113	125	185	177	105	95	87	70	67	66
Length of fore limb	530	540	345	500	515	395	300	305	255	268	220
Width of fore foot	215	223	123	160	165	125	107	117	100	99	85
Length of hind limb	615	597	415	485	507	420	350	295	216	275	210
Width of hind foot at tarsus	130	135	95	112	113	85	80	70	65	67	60
Width of hind foot at end of toes	250	285	170	245	202	177	160	155	135	138	125
Average length of toe flaps	230	230	162	190	196	161	115	102	88	85	68
Length of tail	55	50	53	55	55	47	46	57	25	29	29
Distance between tips of outstretched fore limbs	1770	1740	1205	1445	1370	1085	960	855	705	720	650
Girth of neck behind the ears	580	598	405	475	470	405	360	355	330	332	404
Girth over the shoulders	1150	1205	750	950	930	820	680	600	455	480	465
Girth behind fore limbs	1260	1155	780	850	790	740	625	565	450	425	445
Girth in front of hind limbs	475	480	280	380	365	295	245	225	197	195	168

Measurements of two gray pups, taken at North Rookery, Bering Island, October 26, 1882.

	No. 1697. Male, 38 pounds.	No. 1696. Female, 30 pounds.
	Mm.	*Mm.*
Tip of nose to end of tail	885	865
Tip of nose to fore flippers	425	375
Fore flippers	295	263
Hind legs	275	243
Tip of nose to eye	55	42
Tail	27	20
Girth behind fore flippers	630	570
Ear	38	35

VIRILITY OF BULLS.

While there is thus shown to be a certain instability in the rookery outlines and quite an uncertainty as to the various classes and stages of the seals, except in a *general* way, there is observable a similar lack of strict adherence to the habits as described by many writers, though these may upon the whole be correct. No doubt, for instance, many of the old bulls on the rookery, especially early in the season, stand

up bravely without retreating, even against a number of men, but it is also true that a good many of them do not. Lest the more cowardly conduct of some bulls should be charged to an alleged lack of vitality in those of the present generation, I will only quote what I wrote immediately after my visit to the North Reef Rookery, Bering Island, on June 5, 1883:

Between 200 and 300 old bulls were scattered all over the ground, some sleeping, some fighting; others rose up, somewhat uneasy at our approach; others, again, galloped away as fast as their short feet would carry them, plunging headlong into the water. A few would make a bold stand for some moments and roar at us, but they soon turned, seeking to escape. None of those we approached very closely would keep their position.

I may cite another instance from a date much later in the season, but yet at a time when the females required the full attention of the bulls and on a rookery where the latter were plentiful and vigorous. The observation was made in Sikatchinskaya Bay, Palata Rookery, Copper Island. Mr. Grebnitski had landed on a rock in the rookery to take a couple of photographs, while I, with the men, remained in the boat. The following is an abstract from my diary of August 3, 1895:

It was a sight never to be forgotten. The females from all around rushed into the water pell-mell, while the old bulls were running to and fro trying to keep them back, though in some cases taking the panic themselves and following the example of the females, who made the water fairly boil around the boat by their jumping. On the nearest rocks hundreds of black pups were huddled together as close as they could stand, fearing to go into deep water; but finally driven into it by the advance of the photographing party, they swam with the utmost ease. Of all the many seals covering the rocks around us when we first arrived, only two kept their places. These were an old bull and a matka in heat. Our boat was lying within 20 feet of them, yet they did not mind us, and the courting—the female did the courting—went on, although our presence evidently acted somewhat depressingly on the male, who anxiously kept an eye upon us, while yet unwilling to leave the female. Occasionally he screwed up enough courage to face us and roar defiantly, but as we approached to within 10 feet and I got up in the boat to fire my camera at him, he suddenly thought that discretion is the better part of valor, and plumped headlong into the water on the other side of the rock. He came out and up on the rock, however, a few minutes later and shook the water out of his fur, but the female had apparently become disgusted with him, for, in spite of our retreating, she went into the water shortly after he had returned to her. He then also left for good.

DO ALL BACHELORS HAUL OUT?

The general impression, as derived both from the printed reports and oral communications, seems to be that the vast majority, if not all, of the bachelors haul out on the beaches during the season. It would, of course, be impossible to say whether each individual bachelor does haul out at least once during the season, or whether some of them stay in the water throughout the entire year, but my observations lead me to believe that only a smaller portion of the whole body of bachelors haul out *at any one time.* That a good many of the seals in the water in the immediate neighborhood of the rookeries are bachelors, I know from personal observation, for the two sexes are more easily distinguished at a distance while in the water than on the rocks. These probably all haul out at some time or another. But the question is, does the bulk of the bachelors met with on the feeding-grounds and far away from the rookeries during the breeding season also haul out? I am inclined to believe that they do not, for the following reason:

While it is true that the great rookery on Bering Island was never before "raked and scraped" for the last bachelor seal as it was during the past season, yet it is not denied that a similar difficulty in gathering the requisite number of killables has been

going on for a couple of years, though not to the same extent. Now, if intelligent and honest persons, at the close of the season of 1894, had been asked, while viewing that rookery, whether there were, say, 18,000 bachelor seals (outside the pups of that year) in sight or within a comparatively short distance, they would be obliged to answer no. The question then becomes pertinent: Whence, then, came the 9,000 bachelors killed in 1895 on that rookery (hardly any yearlings showed up at all) and the probable other 9,000 that perished during the winter by being killed by the pelagic sealers, or otherwise? The bulk of these 18,000 must have stayed away from the immediate neighborhood of the island, and as bachelor seals are not known to haul out in great bodies very far from the breeding-grounds there is every reason to conclude that they stayed at sea.

To fully weigh this answer, it is necessary to remember that the bachelor seals, especially the younger classes, have no functions to perform on land during the breeding season. I do not believe that a single good reason can be advanced in defense of a proposition that the hauling out of the bachelor is of any advantage *to the individual*. Nor does it seem probable that all the bachelor seals are subject to a very *pressing* desire to go ashore until the sexual instinct is awakened. The hauling out on dry land by any immature seal is, therefore, only the result of the habit having been inherited. It is therefore likely to be of very varied intensity, and there is nothing intrinsically improbable in admitting that this habit in some, or even in many, is only awakened at the approach of sexual maturity. It must, furthermore, be borne in mind that the bachelor seals require an abundance of food no less than the females. The *nursing* of the young makes it imperative for the latter to visit the distant feeding-grounds, but also to return regularly to the rookery. The bachelor seal, on the other hand, in contradistinction to the old fat bulls remaining the entire season on the rookery, needs a big food supply because he is *growing;* but different from the female, he has no individual business on the rookery. Of course, while there is no advantage to the individual bachelor in hauling out, there is an advantage to the species, inasmuch as it tends to strengthen the inherited habit which insures the return of the necessary number of breeding males at a later age to their respective rookeries, but this proposition does not involve any necessity for *all* to do so.

The above observations and reflections, which are chiefly submitted in order to emphasize that it is necessary to allow for a certain latitude in the habits of the seals, I am now going to follow up with a series of special observations upon certain phases of fur-seal life which I made during the investigations of last summer. They are in part corroborative of observations made by investigators in other localities, particularly the Pribylof Islands, while, in part, opposed to the opinions held by some other observers. In so far as this diversity of opinion affects certain theories only, my deductions will stand or fall upon their own logic; but where there is a disagreement as to the facts I beg to remind my readers that the facts, as here set forth, only relate to the conditions found on the Commander Islands and more particularly on Bering Island. If the facts observed by me differ from those established by others, it does not necessarily follow that one of the two observations is erroneous. I will again recall the fact of the bachelors mixing among the females and the consequent driving of the latter on Bering Island in order to show there are differences between the conditions there and upon the Pribylof Islands.

FOOD OF SEALS AT THE ISLANDS AND EXCREMENTS ON THE ROOKERIES.

The question as to what animals furnish the bulk of the food of the fur-seals can not be solved positively on the rookeries. My investigations last summer corroborated those of twelve and thirteen years ago and tally with those of others, viz, empty stomachs with a few stones in them, and occasionally a few beaks of cephalopods or very rarely the backbone of some unlucky fish. Since, however, as I have already pointed out, the bachelor seals on account of their growth must necessarily take a great deal of food during the summer, the above negative result does prove pretty positively that the seals on the Commander Islands must, *as a rule*, obtain their food so far from the islands that it is thoroughly digested before they return to the hauling-grounds.

I emphasize again the "as a rule," because there are single observations to the contrary. Thus, I was informed on Bering Island that once on the South Rookery a flock of bachelors was so full of octopods that they vomited up quantities of these mollusks while being driven.

It is true the statement that the bachelor seals must necessarily feed because they are in a stage of continued growth is a purely theoretical one, and it has been seriously denied that they feed during the season to any much greater extent than the old bulls. In support of this contention is quoted the observation by the British Bering Sea Commissioners (Rep. Brit. Comm., p. 42) as to the absence of excrementitious matter upon the rookeries. Though my observations, more particularly on the Commander Islands, do not agree with theirs, or Bryant's, I am not going to dispute their accuracy on that account, but I do maintain that their negative result does not prove anything, while my positive observations to the contrary do prove that the seals take nourishment throughout the season. And now for my facts.

Anyone examining the carcasses on the killing-grounds immediately after the killing can not help observing that a good many of the dead seals at the moment they were slain had voided a greater or less quantity of ocher-yellow excrement of a creamy consistency. This observation I have not only made on the Commander Islands at every killing I have there witnessed (and the unpleasantness of handling the seals thus soiled has very vividly impressed my mind), but also on St. Paul Island during the only drive it was my privilege to follow there, viz, on June 26, 1895. Here is the entry relating to the latter observation:

> Mr. True afterwards opened a number of stomachs without finding any food in them, and I opened one, which had just voided a quantity of fluid excrement, with similar result. Quite a number of seals voided excrement of like nature.

On the 2d of August, 1895, Mr. Grebnitski and I landed and established our camp at Babinski Padjom, Glinka Rookery, Copper Island, on the former hauling-ground of the bachelors. A few half-bulls only were located at the eastern end of the bay, all that was now left of this rookery. Here are the words of the diary:

> After supper I went over to the eastern end of the bay, where the polusikatchi above alluded to had been lying (for upon our settling down in their neighborhood all of them sought safety in the sea). The entire narrow and steep beach which lines the precipitous cliffs (300 feet and more), forming the coast here consists of rounded stones of various sizes, from that of a marble to that of a man's head, but averaging perhaps that of a fist, and of a light-gray color. On this pearl-gray ground the station of each half-bull was clearly marked with a brown stain, and all around patches of semifluid excrements were found in various stages of drying up and disintegration. The freshest excrements

were of a blackish-brown color and of a very penetrating and disagreeable odor, while the dried ones were of a pale drab color. In spite of the humidity of the climate things on the beaches dry up remarkably fast and thoroughly, but I suppose it is partly due to the perfect drainage of the sandy or pebbly beaches. * * * The fact is that the excrements contain comparatively few solids and are easily dissipated.

This observation is particularly conclusive because it showed at the well-defined station of each half-bull (hauling up much after the fashion of the old bulls) a quantity of fecal matter in the various stages of disintegration, from that of the semifluid, nearly fresh excrement, to the dry and odorless "chip." Taken as late as August 2, yet a considerable time before the close of the season, it has a very important bearing upon the question.

The third and last entry in my diary in regard to this matter is dated August 22, and relates to what took place during the big drive on that date on the North Reef Rookery, Bering Island, which was witnessed by the officers, including the surgeon, Dr. Lloyd Thomas, of Her British Majesty's ship *Porpoise*. It reads as follows:

There was another matter to which I called the special attention of the English gentlemen while we were on the rookery, viz, the presence—and very offensively smelling presence—of semifluid excrements on the rocks, particularly mentioning the opposite observation of the British commissioners. In fact, the fecal matter was making it very slippery in places.

The argument derived from the alleged absence of excrementitious matter on the rookeries is, consequently, disposed of. It may be well to add the remark that it is more than probable that most of the feces are voided at sea before hauling up, and that, in conjunction with their fluid nature, this explanation accounts satisfactorily for the fact that its presence on the rookeries is not more obvious.

As already remarked above, observations on the rookeries are not apt to furnish positive data as to the nature of the bulk of the food of the Commander Islands fur-seals. That they eat cephalopods is proven by the occasional presence of the beaks in their stomachs, as well as by the above-quoted instance on the South Rookery (p. 69). It is also possible that Mr. Grebnitski's suggestion is correct, that the presence of pebbles in the stomachs is largely to be accounted for by assuming that they are swallowed together with the octopods holding on to them. That they also eat fish, at least occasionally, is also unquestionable. But the following facts will as unquestionably show that salmon and cod, at least, do not furnish any portion of the *regular summer* diet of the Commander Islands seals worth mentioning:

It may not be very much to the point to observe that three species of salmon (*Oncorhynchus*) abound in all the rivers on Bering Island, and that the fur-seals are not observed to feed upon them at the mouths of these rivers; but the fact that the largest salmon river of the island, the Saranna River, is situated less than 7 miles from the largest seal rookery without the seals coming over there to feed upon the enormous numbers of salmon ascending that river, is proof conclusive. The river and the fishing establishment of the natives at Saranna have been described elsewhere in this report, so that it will suffice in the present connection to recall the statement that the annual catch in that river alone varies between 20,000 and 100,000 salmon.

As for the codfish, it is only necessary to state that they are common right off the great North Rookery of Bering Island. On September 16, 1895, we were anchored in 10 fathoms of water less than a mile from Sivutchi Kamen and within hearing of the roar from the rookery. A single cod line over the side of the steamer for a couple of hours brought up three-fourths of a barrel of codfish.

EFFECT OF DRIVING.

One of the questions to which I paid special attention during the past summer was that of the effect of driving upon the vitality of the seals. It has been variously asserted that the repeated driving of the male seals on the Pribylof Islands has resulted in the weakening of the procreative power of the bulls and the consequent degeneration and partial decrease in the number of seals on the rookeries. It has also been hinted that the difference in the methods of driving the seals on the Pribylofs and on the Commander Islands might account for the apparent lesser diminution of the seals on the latter islands. The question is, therefore, one of the utmost importance, and it was in order to specially make a direct comparison between the methods employed on the American and the Russian side that I asked to be enabled to land on St. Paul Island and witness a drive there before proceeding to the Commander Islands. It is, therefore, pertinent to submit a description of this drive, which, thanks to the assistance of the agents of the company and of the United States Treasury, I had an opportunity to follow on June 26, 1895.

It would, of course, be hazardous to base any far-reaching conclusions upon one single drive. As Mr. F. W. True was going to follow up similar studies on St. Paul Island during the whole of the following season, he kindly assented to accompany me on the present occasion, so that he might afterwards inform me how the drive we were going to take part in might compare for severity with those which were to follow later, and which I myself would not be able to inspect.

At 9 p. m. on June 25, in company with Mr. Stanley-Brown, the general agent of the company, we started for Polavina Rookery in a buckboard drawn by a pair of strong mules. The road was to a great extent still covered with snow and water, compelling the driver to pick his way in the dark over hills and marshes. After a trying ride of two hours, during which it was a wonder that we were not upset and spilled by the roadside or into the water which surrounded us on all sides, we arrived safely at the hut, where we found a party of nine Aleuts who had preceded us. After a fitful slumber on the benches in front of the cooking-stove, we turned out with our gang at 2 o'clock the next morning and proceeded to the hauling-ground, where we could hardly discern the various objects in the hazy gray light of the early morning. I quote now from my diary, written a few hours later:

> We move stealthily along the margin of the breeding-ground, which is occupied by angrily bellowing bulls, a few—a very few—females, and still fewer pups, cutting off a small herd of bachelor seals that are skirting the inner edge of the breeding-grounds. At the end of the latter we make a sudden spurt, Mr. True and I running at full speed with the Aleuts for the water's edge, thus cutting off another crowd of bachelors—I estimate in all about 1,000. Then the driving begins by dividing the herd in two (unintentionally) uneven sections, which are driven easily, without special urging, over very even ground.
>
> The seals are of very unequal sizes, there being quite a number of large half-bulls in the flock. In driving, the various sizes become somewhat sorted, inasmuch as the younger and more agile seals keep well to the front, while the large and fat half-bulls bring up the rear. Occasionally a few of these are cut out and left behind—probably in all about 50. No other cutting out or culling is undertaken while the driving is going on, and is practically impossible as long as the seals are driven in as large flocks as these. On the other hand, the driving gang is too short-handed to manage a large number of small sections, as on the Commander Islands. After a moderate drive overland for about three-quarters of an hour, the seals enter a series of shallow lakes, and now the progress is rapid. At 5 a. m. the herd is halted just outside the salt-house at Rocky Point, and the drive is over.
>
> It is noticeable that the seals are nearly as fresh at the end of the drive as at the beginning. The younger seals are quite active; they walk about unconcernedly, and stand well up on their legs, while

the big ones commence to fight each other immediately upon the halt being made. Only one single seal dropped voluntarily out of the line on the road, viz, a large and particularly fat half-bull that got tired very early.

The killing gang arrived from the village in two boats a little after 7 a. m. Six men with nicely finished oaken clubs did the killing while the others were skinning. Mr. True and I took the tally of each of the first ten "pods" of seals as they were separated off from the big herd to be killed. These "pods" consisted of from 15 to 40 seals, averaging about 25. Of these the killing gang clubbed to death those which appeared to come within the required size; the others, being either too large or too small, were allowed to escape to the beach close by. About 50 per cent were thus turned away, about one-half consisting of too small seals, the other half of too large ones. The killing was over at 10.30 a. m., about 500 skins having been secured. It is to be noted that no female was observed among the seals driven.

On the whole the affair was conducted with care, although a certain hurry in order to get through as soon as possible was quite manifest. This haste, probably due to a desire to be back in the distant village before dinner, was responsible for the less deliberate way in which the "pods" to be killed were cut out from the main herd. This resulted in great worry and consequent heating of the remaining seals, which made it necessary to drive them repeatedly into the ice-cold waters of an adjacent pond in order to cool them off. This necessity was rather startling in view of the chilliness of the atmosphere and the long rest enjoyed by the seals between the drive and the killing.

Apart from its length—about 2 miles—this drive must be characterized as very easy. An inspection of the ground over which the drives from some of the other rookeries must travel impressed me, however, with the fact that not all the seals on St. Paul Island are let off as easily. Mr. True also informs me that this impression is correct, and that the drive we witnessed in company was rather easier than the average.

I will now submit a description of a few characteristic drives observed by me on the Commander Islands. The first one (which took place during the palmy days of the business on these islands) occurred on July 13, 1883. A thousand seals were to be taken from the Pestshani hauling-grounds (p. 49), Glinka, Copper Island, to finish up the catch of the season.

We started out at 4 o'clock in the morning from Glinka village. The weather was very disagreeable. A wet, gray fog concealed everything, preventing us from seeing 20 paces ahead. The thermometer indicated +43° F. The path, which in two places rises to over 800 feet above the sea, with a drop of 500 feet and another rise of nearly 200 feet between them, was slippery in the extreme, as the protracted rain had softened the clayey ground. After a very tiresome walk of nearly an hour we halted on top of the third hill, where we had a pretty good view of Pestshani hauling-ground, as the fog had lifted somewhat by this time. The projecting point of the beach, so named, was densely covered by a black mass of bachelor seals, which here haul out by themselves in large numbers apart from the breeding-ground. When the last of the gang of about 20 men had arrived the line of action was decided upon, the chief assigning to each man his duty, and the whole crowd ran or slid down the steep, grassy descent about 700 feet in one continuous slope.

We approached the compact mass of bachelors rapidly. The nearest animals showed signs of uneasiness upon our coming within 50 feet of them. The chief then ordered "Go ahead," and we all made a rush to cut the big herd off from the sea. Those located near the water's edge were successfully intimidated along the whole line and prevented from seeking safety in the sea; they fell back upon those behind, thus effectually barring them, and soon the whole mass was surrounded and slowly moving away from the water until stopped by the precipitous walls of the coast escarpment. The flock thus secured consisted of about 2,000 bachelor seals of various ages. As rigorous orders had been received not to accept skins under 8 pounds, the sorting would have to be very careful, hence the necessity of a large number to select from.

The whole regiment of seals were now divided into companies, which were driven slowly along the escarpment to the steps built of driftwood (see fig. *b*, pl. 58). These were ascended with but little difficulty. Altogether, ten companies were formed, each driven by two men. A space of several hundred yards was allowed between each section.

The progress was slow, averaging less than a mile an hour. There was consequently good oppor-

tunity to sort out any undesirable seals. Thus a number of undersized youngsters were allowed to escape early in the drive. Before ascending the 700-foot slope mentioned above, a halt was made. Soon, however, the climbing began. As may well be imagined, the ascent was very laborious. The angle of the slope was at least 35 to 40 degrees, and the smooth grass and slippery clay made it almost impossible to get a hold with the feet. The poor animals slid backward over and over again, and when they finally succeeded the ground was made smoother and more difficult for those to follow. Moaning, and blowing, and steaming, they press their smooth fore-flippers hard on the elusive clay, and drag the hind part of the body after, while the men beat the ground with their long staves in order to stimulate the animals to further effort. It happens rather frequently that a seal loses his balance, and after a series of bounding somersaults lands at the foot of the hill, accompanied by the laughter and merriment of the Aleuts. I expected every time to see it lie dead with broken back or neck, but every time the involuntary acrobat arose unhurt, looked around in a dazed manner, as if surprised at finding himself so suddenly alone, away from his comrades and tormentors, and scampered away as fast as possible toward the sea.

About halfway up the hill even the larger seals commenced to give out and refused to move farther, from sheer exhaustion. As it would not do to leave these behind, a knock with a club on the head finished their unhappy existence. In a minute, or a minute and a half, the skin had been ripped off from the quivering body and thrown into the knapsack which each man carried on his back. Having arrived at the top, the survivors were given a long rest. The remaining 2 miles of the march were easier, though the last ascent was hard enough on account of the tired condition of the animals. An hour of rest was given before the final killing, to allow the animals to cool off.

This drive can easily be traced on the map (pl. 13), as it followed the dotted line between the Pestshani hauling-ground and Glinka village.

With slight modifications the above description applies to most of the drives on Copper Island during the days of plenty, though the present one was one of the hardest, as it was the longest. A shorter route was afterwards devised, as detailed under the description of the Glinka rookeries (p. 51). Of late years there has not always been enough animals to make it worth while to drive them from Palata over the 1,000-foot pass, and many of the small drives are killed not far from the beach, and the skins carried in knapsacks across the mountains to the salt-houses on the other side of the island. At Karabelni the carcasses were even skinned right on the beach, not 1,200 yards from the breeding-grounds, so that the waves carried them out to sea and occasionally threw them up again on the rookery amongst the living seals. However, even nowadays the seals are driven across the island every time their meat is wanted for food, or whenever the drive consists of so many seals that it is practically impossible for the people to carry all the skins on their backs, as testified by the 700 decaying corpses on the killing-ground at Pestshani salt-house, which I photographed on August 6, 1895 (pl. 58*c*).

To complete the picture of the driving on Copper Island, I may describe one of these small drives, the principal object of which was to obtain fresh meat for the natives. It is thus recorded in my diary for August 8, 1895 (pl. 58*a*):

The weather was just right for ducks and fur-seals, and consequently we started out this morning at 6 a. m. in a drizzling rain. There was no help for it. The drive could not be postponed, and as I was going to photograph, rain or no rain, the cameras were taken along. The weather might possibly be better on the other side of the mountains, but it wasn't.

As indicated yesterday, all the rookeries had to be scraped in order to make even a small drive, and since I could only be in one place at a time, I selected to go with the party taking the drive at Zapadni. Here altogether about 250 animals were finally gathered together, and the driving started in three divisions. This could easily be done, for there were certainly enough people to attend to each division, there being no less than 30 full-grown men and about half a dozen boys. What a difference from former days, when 2 men or boys were all that could be spared for divisions of about 200 seals each! Most of the animals were killable bachelors, a few females and undersized bachelors having

been separated out, as the drive went on, before the steep ascent was reached. Thus far I have only with certainty discovered one female driven across the mountain.

The road was very wet and slippery, both from the long grass and the smooth clay which here forms the chief material covering the underlying rock, and the ascent was consequently a very laborious one. The middle part of it is very steep, and in one place steps have been cut in the ground so as to facilitate the climbing. The altitude of the pass forming the highest point on this drive is about 800′ [760 feet].

The seals soon commenced to give out, and the men then resorted to all sorts of goading them on, short of killing, in order to get as many of the seals as possible alive to the killing-ground at the village, since they wanted the meat badly. Only when a seal could absolutely go no farther, after having been urged on by being poked and beaten with the sticks, only then it was killed and skinned. But not even then in all cases, for if it was a small and therefore particularly tender animal, it was grabbed by the hind legs and dragged along [pl. 62*a*] until some steep declivity was reached, down which it was then flung. Yet a good many had to be killed along the road. Little girls and still smaller boys arrived now with big skin bags on their backs [pl. 62*b*] to carry home the skins and choice parts of the meat. The last division, as well as about one hundred seals from Palata Rookery, reached the level ground behind Glinka village at 10 a. m. and were given a rest there.

At 11 o'clock the final drive in four divisions was begun toward the killing-ground near the beach (not 300 yards) west of the village. Down the steep embankment (fully 60 feet high) the numerous drives have worn a deep channel-like rut in the slippery clay, and down this chute the animals came rushing as if it were a toboggan slide [pl. 63*b*]. They slid down in bunches together, and became piled up at the bottom in big heaps. As they were now driven over the sand of the beach, a few undersized seals and a solitary matka or two were sorted out and allowed to escape into the water, but the final culling was done on the killing-ground. Altogether 47 undersized animals were thus driven over the mountains and finally permitted to go back into the sea.

These young animals let loose on the sandy beach afforded great sport for the younger generation of future seal-killers, if seals there be left when they grow up. Four little tots, five to six years old, with sticks in their hands, tried to drive into the water two young seals too tired to advance farther and asking nothing but to be allowed to lie down and rest. The seals resented the attack, and the four little fellows hit them over the head and the snouts with their sticks, as they had seen their parents do with the big ones, and finally succeeded in driving them into the sea.[1]

The above descriptions give a fair idea of drives on Copper Island as they were and as they are. They demonstrate the tremendous difficulties and the hardships on the seals. A glance at the maps of the Copper Island rookeries and a study of the descriptions I have given of them in another chapter must convince anybody that there is nothing even approaching them on the Pribylofs.

Not so on Bering Island. There the drives are short and easy on the seals. The killing-ground is located scarcely more than 500 yards from the main rookery, and right in front of the summer village where the men live during the sealing season. The longest drive ever taken is only 1½ miles long; the road is over level ground, mostly covered with grass, and the ascent up the coast escarpment is easy and only 30 feet high.

A grave feature of the Bering Island drives, however, consists in the mixing in of females and pups with the bachelors throughout the season. I have elsewhere in this report treated of this side in detail, but it may not be superfluous to give an account of one of the largest drives last summer on North Reef Rookery, Bering Island, which took place August 22.

It being necessary to wait for low water, we did not start until 7 o'clock a. m. The morning was raw (about + 50° F.) and dark, a drizzling fog enveloping the scene and

[1] I am sorry to say that a good deal of unnecessary suffering was caused the animals simply for the fun of it. The people can hardly be blamed. They are certainly not particularly cruel by nature, but on the other hand they evidently have no idea of such a thing as cruelty to animals. They have grown up from babyhood among these scenes, and their feelings are naturally blunted. It must not be forgotten, however, that in the midst of our own civilization more cruelty to animals is practiced in a single day than in a whole season on the seal islands.

making successful snap-shot photography an impossibility. We proceeded, Indian file, to the rookery and in short order drove off nearly all the grown seals located on the reef itself, over 4,000 animals all told. Most of these were females (about 3,000) and bachelors (about 1,000). As it was late in the season, only 8 bulls were caught. As many pups as possible were allowed to escape into the sea, and they availed themselves of the opportunity offered to go off in large flocks. Nevertheless, about 300 pups were driven off to the killing-grounds before they could be released. The whole breeding-ground not located on outlying rocks—and it was now low water—was gone over and swept absolutely clean. Not a living seal, except a few pups too weak from starvation to move, was left on the "Reef."

As usual, the seals were driven in squads of 200 to 300. The length of the drive was only 650 yards and in the cold morning entailed no hardship on the seals. On the killing-ground they were again collected into two large herds. The segregating of the "pods" to be killed was done very quietly and deliberately, without worrying the entire herd. Only about 190 grown males (too large and too small) were allowed to escape, or 20 per cent of all the males driven. Whatever injury the driving might inflict would consequently be trifling so far as the male element was concerned.

But how about the females? More than three times as many females were driven and returned to the sea as there were bachelors to be killed. How did it affect them? Did they suffer much physically? Does the driving of the females seem to have any influence upon their return to the rookery?

These and many related questions will find an answer in the notes and remarks which I wrote down on the spot during an earlier drive on the same rookery, viz, on July 19, 1895.

A separate tally of the number and kind of seals driven is submitted elsewhere (p. 110), and some of the following notes refer to the "pods" therein enumerated, by "pod" meaning each little flock of seals taken out of the big herd to be killed. Each pod usually consists of bachelors, females, bulls, and pups. The killing gang attempt to hit as many of the bachelors on the head with their clubs as possible, while the other classes are allowed to escape. Occasionally the club glances off and hits the wrong animal or, more rarely, a mistake is made in the identification of the animal clubbed. The following remarks are transcribed from the diary without any attempt at classification:

Female seals were accidentally hurt, more or less severely, during the killing. I noted the more severe cases as follows:

In pod 4, 1 stunned; soon recovered and scampered off.

In pod 18, 1 so severely stunned that a man carried her off by the hind legs; recovered in fifteen minutes.

In pod 25 the most severe case occurred; she was perfectly unconscious for a long while; finally sat up, but could not be induced to move; at 2 p. m. I found her still in the same place in a dazed condition.

In pod 31 a female was also badly hurt and bleeding, but not so severely as one in pod 35, which received a very big scalp wound; both ran away with the others, however.

In pod 7 a yearling was so badly hurt that it was thought best to kill him.

In pod 28 a pup was hurt, but I don't believe it was done by clubbing; it was probably injured in the crush. At 2 p. m. I found it still unconscious in the place where it first fell, but as I roused it by lifting it up by the hind flippers it came to and in a little while ambled off.

Returning to the killing-grounds at 7 p. m., I found there a lonely pup roaming about aimlessly. As I saw the other pups escape with and follow the various pods of females, I am inclined to believe that this was the same pup which was hurt and which I was speaking of above. If so, it was very

lively now and made a furious resistance when Abraham Badaef made an attempt to grab it by the hind legs. This he had to be very careful about, for a bite of even such a little fellow—probably not so very many weeks old—might be serious enough; but he finally succeeded and carried the pup off to the beach, where it was left to take care of itself.

I watched the handling of the seals very carefully in order to ascertain the amount of injury they might receive during the affair. The natives were certainly not very particular, much less so than those on St. Paul Island when Mr. True, Mr. Stanley-Brown, and the Treasury agent were observing them, but I can not say that I was much impressed with the severity of the hurt that could have been inflicted. The animals are as soft and pliable as cats, and while there is a good deal of excitement, even panic, and the wildest possible scramble one over the other, none of them seemed to mind it in the least. The whole mass of more than a dozen females would occasionally be piled up on top of a little mite of a pup, but he would immediately pick himself up upon being released and plunge into the seething mass with renewed vigor. The scramble was very suggestive of a game of football, and I feel certain that the seals were less injured externally and internally than the average football player; and as for the exertion, excitement, and fright of the drive having any influence upon the procreative powers of the bulls, as well might it be asserted that the football players impair their virility and render themselves impotent by playing the game.

Many incidents might be quoted to show how little the seals mind the drive and how soon they forget its hardships. On Bering Island I have repeatedly observed half-bulls in a drive trying to mount females in heat during intervals of rest. Another observation is so highly interesting in many ways that I quote it from my diary of July 15, 1895, North Rookery, Bering Island, as follows:

This evening I made a very suggestive observation. While working along the escarpment just west of the salt-house, I came across a small flock of seals left over from yesterday's drive. They had not returned to the sea, but had located on the very extreme northern point of the escarpment, a considerable distance from the rookery [about 250 yards] and 30 feet above the sea. I was quite surprised at finding the flock to be a "harem" consisting of 1 bull and about 20 females. I could not count their number exactly, as I did not want to disturb them, but there were about 20 females, and I heard at least 1 pup, though I did not see it. I took up my position some distance off and watched them. Several of the females were in heat and were alternately teasing the bull, getting him by the throat, but he was kept too busy running around trying to keep the harem together, as some of the females were evidently anxious to return to the rookery. He, on the other hand, was plainly well satisfied with the location and intended to hold it. * * * Now, these animals were driven yesterday and not let go until after they had reached the killing-grounds [only 220 yards away from their present location]. In view of the above observation, it seems absurd to assume that the driving had injured them in the least. Nor can this bull be accused of sleepiness—yet bulls are few on the rookery—for he was kept very busy indeed.

His vigilance did him no good, however, for the females escaped to the rookery during the night, and the place was entirely deserted when I visited it next morning.

It is certainly very significant that on Bering Island over a thousand pups are yearly driven to the killing-ground, there to be released, without any visible harm coming to them worth mentioning. If these newly born seals can stand to be driven three-fourths of a mile from Kishotchnaya and to be repeatedly trampled upon by the larger ones piling up four high, or more, on top of them, it stands to reason that the vigorous holustiaki—or even the females—*as a whole* can suffer but little injury from the same cause.

Before leaving this subject it may be well to recall the following points:

On Bering Island the drives are easy, while on Copper Island they are exceedingly severe. Yet on Copper Island the bulls and half-bulls are plentiful, while on Bering Island they are comparatively scarce. The severity of the driving, therefore, does not seem to bear any relation to the relative plenty or scarcity of mature bulls on the rookeries.

Again, on Bering Island breeding females and pups are always mixed with the bachelors in the drives. This, on the other hand, does but seldom happen on Copper Island, even nowadays. Yet the female seals on Bering Island are proportionately more numerous and do not appear to be less vigorous or less prolific than on Copper Island. Moreover, the productivity of the Copper Island rookeries has evidently suffered more of late years than those of Bering Island. The driving, therefore, does not seem to be responsible for the depletion of the rookeries.

DOES THE FEMALE SEAL NURSE HER OWN PUP ONLY?

The question whether the mother seal nurses her own pup only, or whether she will allow other pups to suck her promiscuously, has been causing quite a controversy. To persons who have not studied the question on the rookeries with the closest attention it seems an absurdity to suppose that a female seal, after an absence of a day or more, during which her pup has been mingling with the thousands of other pups and roaming all over the rookery with them, should be able to find it and recognize it. During my visit to the islands in 1882–83 the question was not up, and I had paid no special attention to it. On thinking of the multitudes of pups which I had seen podded together in those days I was, therefore, on theoretical grounds, strongly inclined to side with those who deny that such a search and recognition takes place, and I so expressed myself to Mr. True when we talked this matter over on our way to the Pribylof Islands. I resolved, however, to pay special attention to this question. The great difficulty lies in the impracticability of so singling out a number of *mothers with their young* and so marking them that they could be individually recognizable at a distance and for several days at least. Only in this way would it be possible to gather proof conclusive to others than the observer himself, particularly to persons who might not be willing to accept his other observations as final.

My observations on the rookeries, however, have been sufficient to convince me that I was wrong in doubting the ability of the mother to find and recognize her individual offspring among thousands of pups of identically the same appearance. Some of these observations noted down in my diary follow here in the very words written down on the spot.

Kishotchnoye Rookery, Bering Island, July 16, 1895.—Old bulls are certainly scarce and of holustiaki I have thus far seen none. Pups are very plentiful, and the females do not appear to have been barren when they arrived. The pups are already "podding," and the two backward extensions on either side of the "parade" consist chiefly of pups.

The matki come and go, especially those that are wet and apparently just in from the sea, while the dry ones [meaning those with the fur dried from having been longer ashore] lie still, sunning and fanning themselves.

Right in front of me, about 200 feet away, is a small group of 6 dry matki and close to them a pod of about 50 pups. About 20 feet to the left is a lonely sikatch; then another similar group of dried matki and pups. The dry mothers are silent and lie down sleepily; the bull has not changed his position, his nose sticking right up into the air, during the last hour; he probably sleeps. Occasionally a wet matka [i.e., with wet fur] comes ambling up from the sea, and fighting her way through the harems next to the water's edge finally reaches this group, which is located at the posterior left-hand horn of the breeding-ground—the very edge of the rookery. Such a matka will stop occasionally, shake her head and bleat (apparently in anger); a few pups will rush at her; she noses them; finally shows her teeth, bleats, shakes her head and ambles away to repeat the performance at the next pod. A matka with only a large wet spot on the hind quarters [she had consequently been a considerable time out of the water] came up in this fashion to this pod, and after nosing about in the midst of it finally grabbed a pup by the skin of its neck, much to the disgust of the pup, apparently, and carried the little one off, part of the way holding it in her mouth, part of the way pushing it ahead between her

fore flippers. In this manner she brought it through several pods of pups and groups of females down to an old sikatch, a distance of fully 150 feet, where she lies down, but I can not see whether she is nursing the pup, as she is down in a hollow. I see, however, that the pup tries to escape—probably wants to go back to play—but is brought back every time.

Some of these wet matki will stop several minutes in front of four or five pups and nose them repeatedly, as if in doubt, before they go away. * * *

There is a remarkable individual variation in the voice of the females.

At 1 o'clock p. m., I moved to the northern end of the rookery. Among the notes written down there I find the following:

The pups were very active, running to and fro, but I could not discover that any of them went very far away from where I saw them first. On the other hand, females hauling out of the water were constantly traveling all over the rookery, calling and bleating.

Later in the season similar observations were made on the little South Rookery, Bering Island (August 17, 1895). The notes then written down also contain some reflections of a general nature upon the question. It is hardly necessary to add that upon further reflection I still adhere to the opinion then expressed—an opinion which may possibly have some weight, written as it was in plain view of the seals it refers to. That part of my diary reads as follows:

I was able to get very close to the grounds, which were occupied by mothers and pups only. A good many of the latter were in the water, but there was also quite a large pod of smaller pups at the posterior edge of the herd [near the place where I was watching]. I was again impressed, as before on Kishotchnaya, by the action of the females and pups when the former haul up from the water and go in search of the young to nurse it. The ground is here so small that it is a comparatively easy task for the mother to find its young, and I consequently observed several dripping-wet cows nursing pups. The mother in coming out of the water made straight for the pod of pups and the usual performance of pups rushing up and, upon being nosed at critically, refused, whereupon her search continued, was gone through.

So much is absolutely certain, that the females do not nurse the pups promiscuously. I am thoroughly convinced by what I have seen that the mother wanders considerable distances and spends much time in searching for her own individual child. Whether a mother who had searched in vain for a long time, and whose milk was pressing her very strongly, might not finally give in to the importunities of a particularly hungry pup is a question which it will probably never be possible to answer definitely, but I think such cases [if they occur] are the exceptions; the rule is certainly the reverse.

To the above I need add but little by way of argument. Persons who reject it on purely theoretical grounds have adduced much testimony to show how some other animals do not discriminate between their own young and those of other mothers, but anyone who has studied the habits of wild animals will know how utterly futile such an argument is, and how absurd it is to conclude from one species what are the habits of another.

I may finally, however, call attention to the fact that the opinion here held has of late received strong confirmation. I refer to the thousand of starving pups of late years found on the rookeries; for if the females were willing to nurse the pups of other mothers as well as their own there would seem to be no reason at all why any pups should starve to death.

MORTALITY OF PUPS.

The above reflection leads me to the question of the mortality of pups on the rookeries. With the reports of the appalling loss of pups on the Pribylof Islands fresh in my mind, one of the first inquiries I made on Bering Island, upon my arrival, naturally was whether any unusual mortality had been observed there.

The answer came from an authoritative source that—

No abnormal mortality had been observed among the pups on the Commander Islands. A few are killed on the rookeries by the old bulls stepping on them, or otherwise, and others are caught in the breakers and surf and are thrown on the beaches. The skins of these are all utilized and their number on each island averages about 200 a year.

This was also the opinion of everybody I spoke with.

On August 1 and 2, 1895, Mr. Grebnitski and I visited the Karabelnoye Rookery on Copper Island, i. e., the eastern end of it, particularly the beach near the "Stolp" and the first breeding-ground. On the 1st of August we found "two dead pups, one with the placental cord still attached, but too much decomposed to make an examination of the cause of death possible."

The next day we visited the same place again:

A few more dead pups were seen on the rookery this morning, all decomposed. They are easily accounted for, and the native was undoubtedly correct who stated that he had observed that the great number of sikatchi [remember, there were plenty of bulls on the Copper Island rookeries] caused so much fighting among them that many pups which came in their way got trampled upon and killed. The number, however, is plainly insignificant.

On August 22, 1895, in company with the captain, Mr. Francis R. Pelly, and several of the officers of H. B. M. S. *Porpoise*, I attended a large drive on the North Reef Rookery, Bering Island, the same of which I have given a description previously in this report (pp. 74–75). In order to fully appreciate the account which is to follow, it is necessary to remember that this great rookery covers a long rocky reef and that low tide (the difference between high and low water being about 4½ feet) uncovers a long stretch of rocky beach which forms the favorite roaming and playing ground for the pups. (Compare photographs 19*b* with 22*b*.) It should also be borne in mind that, as I have stated previously, it was extreme low water at the time we went with the natives on the rookery to take the drive.

When all the animals had been driven off, I remained behind to investigate. On the rookery ground I was startled by the great number of dead pups. I was wholly unprepared for this, because at the great distance from which it had become necessary to watch the rookeries here the small bodies of the dead seals have not been noticeable; in fact, I do not see how in the binocle they could have been distinguished from sleeping ones.

Those lying in a windrow along the high-water margin of the rookery were most conspicuous. These had evidently been washed ashore. A good many of them were in an advanced stage of putrefaction—some entirely flattened out and without hair. But an equal proportion had evidently died more recently, being in good condition. There was another class of pup carcasses, viz, those which were lying dead upon the higher portion of the breeding-ground, away back from the water's edge. These were mostly all in good condition and appeared as if they had died within a few days.

When the seals were driven off, as many pups as possible were allowed to escape into the sea, and they availed themselves of the opportunity offered to go off in large flocks. But there was a considerable number of pups staying behind singly, which upon our approach, made but feeble attempts at getting away. Evidently something was the matter with them. Upon a closer examination they were found to be very weak, and their thin, pinched appearance was at once noticeable. They were starving; their shoulder blades and ribs and hips were sticking out in strong contrast to the rounded and plump forms of those scampering off with the others. Upon handling

the carcasses, both in the windrow and on the higher ground, the same state of affairs was apparent, viz, extreme leanness and emaciation.

After the rookery had been completely cleared I took my notebook and walking along the beach (starting at the south end, west side) began to count the number of dead pups, making a distinction between those in good condition and those in an advanced stage of decay. I had gone about half way round and counted about 200 of the former class and 150 of the latter, when the starshena arrived and said he had orders from the kossak, Selivanof, to ask me to leave the rookery at once.

It was evident later that Selivanof was uneasy because he thought that the number of dead pups might in some way become charged against the management, for he tried to make the whole thing a small affair and explained to me that the number of dead pups was due to their being trampled upon by the sikatchi. But for three very good reasons this theory does not hold: (1) There are now very few sikatchi on the rookery at all, entirely too few to be able by any possibility to even kill a small fraction of the pups which have recently died; (2) if this trampling caused the death of so many pups, how many might we not expect in a drive like the one to-day, in which hundreds were trampled upon, not once, but over and over again, yet not a single dead pup was found in the wake of the drive; (3) this explanation does not account for the emaciated condition of the bodies of the dead ones.

Seeing the necessity of complying with the order to leave the rookery, I could not finish my count. I am pretty positive, however, that the following estimate is not much out of the way. I may preface it by saying that the number of dead bodies on the east side appeared to be about double that on the west side.

Dead pups on west side, counted, about	350
Dead pups on east side, estimated, about	700
Dead pups on high ground, estimated, about	200
Total	1,250

In leaving the rookery I took from the high ground two bodies, which seemed quite fresh and from which, therefore, it would seem possible to determine the cause of death. In lifting the second body up by the hind flippers I was somewhat startled to find it still gasping, though it was much too weak to give any signs of life when lying on the ground. I carried it up to the killing-ground, where the rest of the company had congregated, but the pup had died before I reached them. The other pup had died apparently during the previous night.

The doctor on board the *Porpoise*, Surgeon Lloyd Thomas, kindly consented to attend the post-mortem. On viewing the opened bodies he agreed with me that death was due to inanition—lack of food. They were starved to death. There was not a trace of fat left in the tissues under the skin nor on the muscles. The extreme leanness of the carcasses was very noticeable. Both of us afterwards commented upon the plumpness of the average pups as they appeared in the drive.

I satisfied myself while on the rookery that the fresh bodies in the windrow were in the same condition, and the fact that they were thus thrown up on the beach by the sea signifies nothing, for we had had no severe weather as yet, and it is therefore impossible that these pups could have been killed by any "surf nip."

It may be well to remark right here that the fact that these bodies were found in a windrow at high-water mark does not imply that they died in the water or were killed by the sea. I have explained above that at low water a long stretch of beach is bared, upon which the pups roam about and play. Naturally, a good many of the

starving pups died there at ebb tide and their emaciated bodies were thrown up by the rising tide. It may even be reasonably supposed that these hungry pups would attempt to keep as close as possible to the water's edge, to beg nourishment of the females landing.

On the 16th of September I had another chance to inspect the North Rookery. My experience was as follows:

Very few seals were seen on the rookery, only a few thousands all told; the "sands" were almost entirely deserted, nor were any seals to be observed in the sea. Those on the reef were cows and pups, the majority of the latter now gray. One or two old bulls were seen and half a dozen large four or five year olds mingling among the females, apparently playing sikatchi. I found a great number of dead pups; there were at least twice as many as on August 22. All, or nearly all, were lying in windrows. Curiously enough, there were no very fresh bodies which might have been killed by the recent northerly swell; all I saw were dead at least one week. It was also notable that nearly all were black, only here and there a gray one.

After all, the absence of fresh bodies does not signify much. I have no doubt that most of them were eaten or carried off by the blue foxes. Since the decrease in the number of seals killed the natives on Bering Island have utilized every seal carcass, salting the best parts for their own use and putting the rest, including the entrails, into holes in the ground for winter food for the sledge-dogs. The foxes in the neighborhood of the rookery, instead of feasting on the carcasses on the killing-grounds and elsewhere, are therefore reduced to making a precarious living out of what they can snatch from the rookery. There being now only a few old seals on land, the foxes and their young, at this time nearly full grown, naturally clean the ground very early every morning of every pup dead during the night. The flock of large sea gulls (*Larus glaucescens*), always present on the rookery, also dispose of many bodies. It is therefore perfectly safe to assert that a great many more seal pups have died than any census based on the dead bodies present on the rookeries will account for.

It may be observed in the present connection that the bodies of even grown seals disintegrate and disappear with amazing rapidity. The combined efforts of the foxes, the birds, the staphylinid insects, and the fly larvæ reduce a carcass in very short order to a skeleton. During the winter the bones become scattered. If they are lying on or near the beach the furious winter surf sweeps them away; if they are farther away the decaying rank vegetation covers them up. During the winter the waves wash over the entire "reef" and the "sands" as well, and not a trace of the starved pup carcasses will be found on the beaches the next season.

It is a curious fact that the natives and the kossak in charge of the rookery were trying to make light of this state of affairs, although the very fact that the latter prevented me from finishing the count is evidence enough that he was aware of it. As mentioned in the abstract from my diary, he suspected that the great mortality might be charged against management. I have shown that his argument that the pups were being trampled to death on the rookery has no foundation in fact, but I did not mention, however, his answer to my question why he thought so. It was to the effect that the flattened condition of the dead pups showed that they had been trampled upon. Now, it is quite true that these half-decomposed bodies present a very much flattened appearance, but that is not surprising when we consider the amount of cartilage in their skeleton. Moreover, there is no doubt that they have been trampled upon, but that took place *after they were dead.* After I had demonstrated to Selivanof and some of the natives that the pups had died from starvation and

not from any injuries received, there was evidently a load taken off their hearts, and lamentations over the great number of dead pups were heard all around. I mention this incident chiefly to show how little dependence can be placed upon the observations made by the natives, and more particularly upon their deductions, or the explanations they see fit to make.

From the above it may be regarded as well established that during the past season an unusual mortality took place among the seal pups on Bering Island, and that they died of starvation. There seems but one reasonable explanation of this phenomenon, viz, that they starved because their mothers were killed, and as they were not killed on the island there seems to be no other logical conclusion but to assume that they were killed by the pelagic sealers.

ALLEGED CHANGES OF HABITS.

During the recent discussions relative to the habits of the fur-seals and to the seal fisheries, it has been asserted by various persons that the habits of the seals have undergone, or are undergoing, material changes. Curiously enough, such changes have been alleged by both sides, but while one side attributes certain alleged changes to the disturbance of the seals on the rookeries, the other side insists that certain other alleged changes are due to the interference of the pelagic sealers.

It must not be forgotten that the habits of the fur-seals at the present time are the result of a long evolution, which dates back possibly millions of years. The habits of the North Pacific and South Pacific seals in most essential points are alike, and as these seals belong to very distinct species it is practically certain that these habits were formed before these species had emerged from the common ancestral stock. This separation probably dates back to the time when the North Pacific seals became geographically shut off from intermingling with the southern forms. From that early period the differentiation of the local habits of the former must have gone on for ages, until now there is inborn in every seal an instinct which is the inherited accumulation of the doings of tens of thousands of generations repeated every year.

It must, moreover, be borne in mind that the fur-seals are gregarious animals. Such animals always act in flocks; their habits are the habits of the flock. Individual deviation from the habits inborn does not materially affect the habits of the whole community. To effect a change in the habits of such a species it would be necessary not only that the bulk of each yearly class should change their habits in the same way, but also that the causes should continue long enough to allow the change to be transmitted to the offspring through an unknown number of generations. This is particularly true where, as in the present case, the disturbing causes mainly affect the male sex.

The first detailed description of the habits of the northern fur-seal, after Steller's account, is, as I have shown (p. 60), by Veniaminof in 1839. The next by Bryant (1870) and Elliott (1874). No change of habits is alleged up to that time. In fact, these changes are supposed to have taken place during the last five to ten years.

The theoretical considerations presented above have not been submitted with any intention of overriding by *a priori* reasoning any statement of alleged facts, though it is believed that its soundness is unassailable. It is only my intention to show the utter improbability of any change of habits within the short period in which man has interfered with the fur-seal in order to demand strong proof in support of the alleged

changes. In view of that improbability we can not accept a change of habit as the explanation of certain phenomena unless demonstrated beyond peradventure, or no other reasonable explanation can be furnished. Much less can we be expected to admit such changes simply upon hearsay evidence or speculations of a general nature.

Now, for the alleged changes in so far as they have had reference to the habits of the Commander Islands seals.

The decrease in the number of killable seals on the rookeries has been attributed to their having been driven off to seek other haunts. It is alleged that they are staying at sea and that they are forming rookeries on the Kamchatkan coast.

The evidence in support of these contentions are of the most indefinite kind. On a couple of occasions fur-seals are *believed* to have hauled out at certain uninhabited rocks on the eastern coast of Kamchatka. In the first place, the accounts are so devoid of details that it is impossible to attach much importance to them. In the second place, granting that fur-seals do haul up there occasionally, what scintilla of proof is there that they have not done so always?[1] As a matter of fact, I heard these rumors of fur-seals hauling out on the coast of Kamchatka during my first visit, in 1882–83, and I know positively that Captain Sandman contemplated a trip to go in search of the alleged rookeries as far north as the island Karaginski. Nearly the whole eastern coast of Kamchatka, for a distance of more than 400 miles, is almost entirely uninhabited and very seldom visited by man.

The other evidence offered is the fact that lately the sealing schooners have been found taking fur-seals during the summer months off certain capes in Kamchatka, notably Cape Shipunski. Here the same objection obtains. What proof is there that seals might not always have been taken there in summer? Moreover, is it certain that the seals taken there by the schooners represent the bulk of the "killables" of the islands? On the contrary, it is probable that these locations of schooners indicate the feeding-grounds of the females, as hinted at in another chapter of this report. Krashenninikof's statement that "none of them are to be seen [on the east coast of Kamchatka] from the beginning of June to the end of August," only relates to the immediate coast itself and not to the open sea, where pelagic sealers make their catches.

The explanations offered of these alleged, but utterly unproven, changes of habits are diametrically opposed to each other. Those postulating that the regulated driving and killing of the bachelor seals on shore is causing the decrease of seals on the islands, explain that this interference with the seals has led them to seek other haunts—in this case the coast of Kamchatka. There was never any evidence that seals were driven away from any place frequented by them habitually and took up their abode habitually in some other place. Elliott (Monogr. Pribyl., 1882, p. 109, footnote), it is true, in speaking of the "rapacious hunters" that were drawn to the Commander Islands, states as follows:

> They appear, as near as I can arrive at truths, from the scanty record, * * * to have killed many and harassed the other fur-seals entirely away from the island; so that there was an interregnum between 1760 and 1786, during which time the Russian promyshleniks took no fur-seals, and were utterly at loss to know whither these creatures had fled from the islands of Bering and Copper. When they (the seals) began to revisit their haunts on the Commander islands, I can find no specific date. * * * I think, therefore, that when the fur-seals on the Commander islands became

[1] They apparently did so occasionally more than 150 years ago, if Krashenninikof's statement, that "they seldom come ashore about Kamchatka," means anything.

so ruthlessly hunted and harassed, shortly after Steller's observations in 1742, then they soon repaired, or rather most of the survivors did, to the shelter and isolation of the Pribylov group, which was wholly unknown to man.

As will be shown in the historical part of this report (p. 90), the seals, as a matter of fact, never fled from the islands of Bering and Copper, and Elliott's statement rests on a misapprehension. In the very year 1786, when Pribylof first discovered the islands which now bear his name, there returned to Kamchatka two vessels, loaded with fur-seal skins which could only have been taken on the Commander Islands, viz, one belonging to Protassof, "the cargo consisting chiefly of fur-seals," and one belonging to Shelikof, with no less than 18,000 seal skins. Pribylof, with his cargo of over 31,000 seals from the new islands, did not return until several years later.

The other explanation offered by some of those who ascribe the decrease of the seals on the rookeries to the interference by the sealing at sea, rests on an assumption that the sealers, by stationing themselves at intervals across the path of the seals on their northward migration, actually cut the seals off from the islands, thus forcing them to go elsewhere, or, in the case of those finally reaching the islands, materially delaying them on the way. It would seem that to anyone who has seen the way in which seals travel during their migrations it would be plain that it would be impossible for many times the number of sealing schooners now in existence to effectually block the progress of the migrating herds. It may well be that the positions of the schooners if plotted on the charts would show them to thus stretch across the path of the seals (it has been so asserted in Russian reports), and the large marks on the chart may well convey such an impression, but at sea the thing is quite different.[1]

This last explanation hints at the other alleged change in the habits of the seal, viz, an increasing lateness in the arrival of the bulk of the seals and a corresponding lateness in many of the phenomena of seal life on the islands. It is utterly inconceivable, however, that the sealers can even delay the bulk of the migrating herds *materially*, and the explanation, therefore, would not explain, even if the allegations of the increasing lateness of the phenomena alluded to could be substantiated, and in my opinion they can not.

A glance at the table of seals killed on North Rookery, Bering Island, during the season of 1895 (p. 110) shows that nearly one-third of the total number of skins was obtained between the 22d of August and the 13th of September (the skins being shipped September 16); in other words, during 1895 nearly one-third of the skins was taken after the time when the skins were usually shipped. Thus, in 1894 the skins were shipped August 27; in 1893, August 22; in 1892, August 24. The earlier records to which I have had access are rather incomplete, but from 1877 to 1882 the seal skins were shipped from the North Rookery, Bering Island, on the following dates:

1877	Aug. 26	1880	Aug. 20
1878	Aug. 16	1881	Aug. 13
1879	Aug. 29	1882	Aug. 16

It will be seen that even in the palmiest days of the rookeries, long before the advent of the pelagic sealers, the shipping dates do not differ materially from those

[1] For the contemplation of those who believe in the schooners being able to cordon the sea so as to actually intercept the seals, I submit the following: In the latter part of July, 1892, to the end of August, numerous schooners killed seals south of Copper Island. If the position of the daily catches of eight of them be plotted down on a chart, it will be seen that they covered pretty evenly an area of 13,000 square nautical miles (roughly speaking). As their combined catch amounted to about 4,000 skins, it is plain that they secured about one seal on every 3 square miles (see map, pl. 1).

of the years 1892 to 1894. The lateness of the catch in 1895 is therefore abrupt and exceptional. There is a great deal of difference in the dates upon which the hunting ceases, even in former years. Thus, on Glinka, Copper Island, the catch was all in on the following dates:

1877	June 30	1880	Aug. 7
1878	July 12	1881	July 30
1879	Aug. 1	1883	July 13

But the lateness of the Bering Island season of 1895 is not explainable in that way either, for no amount of backwardness of the season would account for the catch after the middle of August. The summer of 1895 was certainly a cold and late one, and the snow was in places lying down to the water's edge the entire summer; but the season of 1879 was also late, according to the records, and the "year remarkable for much snow," yet the sealing season closed on both islands on August 2. There must consequently be some other reason for the lateness in 1895.

Here is where the plea comes in that the killable seals in 1895 arrived later on the rookeries than in former years. In answer to this I would like to ask the question: Is there anybody familiar with the North Rookery, Bering Island, who would deny that it would have been feasible in any previous year to have obtained there 2,670 skins between August 13 and September 13, if an attempt had been made to "scrape and rake" the rookery to the same extent as in 1895? However, the table of the seals killed on that rookery in 1895 (p. 110) directly disproves the alleged late arrival of the killables, for it will be seen that the proportion of the killables to the other classes of seals driven was decreasing toward the latter part of the season, instead of increasing. Thus, before August 12 the average proportion of killed seals to those escaping was as 1 to 2.2, while after that date it fell to 1 to 3.75.

The following table shows how exceedingly variable the first arrival of killables on the rookeries really is:

First drives on Bering Island, North Rookery.

Date.	Number of skins.	Date.	Number of skins.
1877, June 29	911	1890, May 25	41
1878, June 3	3	1891, May 29	51
1881, May 31	221	1892, June 1	3
1882, June 8	512	1893, June 24	830
1883, June 19	1,552	1895, June 13	110
1889, June 19	1,103		

The true and only explanation of the exceptional lateness of the season on Bering Island lies in the fact that killable seals, especially the younger classes, had become very scarce, and that, consequently, in order to get as many skins as possible—the company and the natives being equally eager to make up the threatened deficiency—seals were killed until the advanced staginess of the skins put a stop to it, as proven by the fact that in the last drive, in which 194 seals were killed, 51 were more or less stagy.

This statement recalls the other change alleged to have taken place. It is asserted that the skins become stagy later in the year now than formerly.

In order to fully weigh this allegation it is well to call to mind the fact that there are very few detailed and definite observations upon this point so far as the Commander Islands are concerned. Nowhere do we find any series of observations

concerning this question continued through a number of years. It can not be too often emphasized that there is a great latitude of date in the events of seal life,[1] and assuredly the beginning of the stagy condition of the skin is no more bound to a rigid observation of the calendar than the other phenomena. Moreover, we do not at all know the causes which are responsible for these fluctuations; we do not know the conditions which accelerate the advent of the stagy season or postpone it. Possibly cold and damp weather may retard it. In that case we might expect the skins to become stagy somewhat later in 1895. The only definite record, so far as the Commander Islands are concerned, that I am aware of is the statement by the British Bering Sea Commission (Rep. Behring Sea Comm., 1893, p. 50) that "In 1891 we found the 'stagy' season was just beginning on the Commander Islands on the 1st of September." In 1895 there were 14 stagy skins taken in the drive on September 10. The "beginning" must, therefore, have been somewhat earlier—enough to show that in this respect 1895 is not extravagantly late.

The lack of reliable information concerning the beginning of the stagy season in earlier years is easily explainable by the fact that the killing season was over long before there was any suspicion of staginess. The question then was not at all "When does the stagy season begin?" but, on the contrary, "When does it end?" The reason of this was that the natives were anxious to begin the autumnal catch as early as possible, in order to get fresh meat, which they had been obliged to be without since the end of the killing season. Thus I find in the records of Bering Island station for 1878 that on October 13 it was contemplated to take a drive in order to get fresh meat. The "chief wished first to ascertain how skins looked at present, supposing they were too stagy yet," and accordingly went himself to the rookery, whence on the 16th he returned with 9 skins, reporting that "fur was good." The drive was therefore made and 520 seals taken on October 18.[2]

The explanation of the fact that nowadays many phenomena appear to happen later is easy enough. During the years of plenty very little attention was paid to them except in the most general way. Such a thing as detailed observations and records throughout the season for a number of years sufficient to furnish exact data for reliable deductions were (and, as a rule, are yet) unknown. This is particularly true of phenomena happening after the finishing of the catch. But now, in the days of threatened commercial extinction, when the rookeries and the seals are under constant and anxious inspection, many things appear unusual and new. The killing season being extended in order to fill the required complement of skins, the impression easily takes hold that the phenomena particularly noticed during the thus belated season are themselves likewise belated.

[1] The first arrivals on Bering Island rookeries are shown in the following statement:

Date.	Rookery.	Arrivals.	Date.	Rookery.	Arrivals.
1879, May 5	North	2 bulls. 1 bachelor.	1882, April 19	North	4 bulls.
1880, April 27	do	3 bulls.	1883, May 23	South	2 bulls.
1881, May 20	do	2 bulls.	1895, May 10	North	1 bull.

[2] The difference from the Pribylof Islands will be noted, as in the latter the natives were allowed to take seals for food in the stagy season. (See, for instance, Fur Seal Arb., v, pp. 714, 715.)

FEEDING-GROUNDS OF COMMANDER ISLANDS SEALS.

It was formerly held by those who had anything to do with the Russian fur-seals that the females only went a comparatively short distance from the islands to feed. This assumption was based upon no observed fact whatsoever, and was only a general expression of the total ignorance of the true location of these feeding-grounds.

When the Canadian sealing fleet, in 1892, in a body resorted to the Commander Islands, after having been excluded from the eastern portion of Bering Sea, an inkling of the truth was felt, and undoubtedly to some extent influenced those who were responsible for the 30-mile zone fixed in the Russian-British *modus vivendi* of 1893. But it was not until the logs of the more successful schooners had been published and their positions at noon every day, with numbers of seals taken during the past 24 hours plotted on the charts, that the true status of affairs was made clear. It was then manifest that the bulk of the catch was taken on a comparatively limited area south of Copper Island, approximately bounded by 52° 30′ and 54° 30′ north latitude, and by 165° and 170° east longitude. The richest hauls, however, were made within a much more restricted area south and south-southwest, and on the line between this area and the rookeries of that island. As a matter of fact the overwhelming majority of the skins were taken more than 30 miles distant from the island, and most of the skins that were taken closer in were secured by those of the schooners that found it more tempting to raid the rookeries from a safe distance. The time of the season during which the fleet operated that year was chiefly during the months of July and August. There is, therefore, not the slightest doubt about the correctness of regarding the area as above limited as the feeding-grounds of the seals frequenting the Copper Island breeding-grounds (pl. 1).

The season of 1892 failed to throw much light upon the question where the Bering Island seals go to feed during the same months. The *Vancouver Belle* made a reconnaissance to the northeast and north of Bering Island, at a distance varying between 20 and 100 miles, but obtained only a few (13) stray seals, and hastened back to the Copper Island grounds. The *Maud S.* made a similar trip of exploration around Bering Island with a similar result (27 seals). The experience of the fleet, however, demonstrated pretty clearly that the Bering Island seals do not go to the Copper Island grounds to feed. It seems that the *Henry Dennis* was on or near the Bering Island feeding-grounds, for between August 1 and 7 she took 189 seals in a restricted area a little more than 100 miles due northeast of the Bering Island North Rookery.

The experience of 1895 seems to show that the Bering Island feeding-grounds are somewhat more distant and more extensive than the Copper Island ones, for the *Jane Grey* took 65 seals between August 16 and 21 about 25 miles from the Kamchatkan coast, east of Cape Afrika, while the *Ida Etta* obtained 180 skins between August 20 and September 4, 20 to 30 miles northeast and east from Cape Nagikinski, as detailed elsewhere in this report.

IV.—THE RUSSIAN SEALING INDUSTRY.

HISTORICAL.

Even before the discovery of the Commander Islands, in 1741, the fur-seals were known to and hunted by the natives of Kamchatka. Krasheninnikof (Hist. Kamtschatka, 1764, p. 124 seq.) refers to this catch as follows:

> The sea cats are caught in the spring and in the month of *September*, about the river *Shupanova;* at which times they go from the *Kurilskoy* island to the *American* [i. e., Commander Islands] coast: but the most are catched about the cape of *Kronotzkoy*, as between this and the cape *Shupinskoy* the sea is generally calm, and affords them properer places to retire to. Almost all the females that are caught in the spring are pregnant; and such as are near their time of bringing forth their young are immediately opened, and the young taken out, and skinned. None of them are to be seen from the beginning of *June* to the end of *August*, when they return from the south [!] with their young. * * * They seldom come ashore about *Kamtschatka;* so that the inhabitants chace them in boats, and throw darts or harpoons at them, which stick in their body; to this harpoon is fixed one end of a rope, and the other is in the vessel; and by this rope they draw them towards the boat; but here they are to be particularly cautious whenever they chace one, if he comes near, not to suffer him to fasten upon the side of the boat with his fore paws, and overturn it; to prevent which some of the fishermen stand ready with axes to cut off his paws.

In later times there has been no such regular catch of fur-seals on the Kamchatkan coast, for the reason that now the whole region from the Bay of Avatcha to the mouth of the river Kamchatka is entirely uninhabited.

Following the discovery of the Commander Islands numerous vessels were fitted out to hunt fur-bearing animals on these islands and, later, to lay in provisions of sea-cow meat for use in their protracted journeys to the Aleutian Islands farther east (see Stejneger, American Naturalist, 1887, pp. 1049–1052). It does not seem, however, as if the fur-seal skins were in demand. The skins were not particularly valuable; the sea-otters and blue foxes were still numerous; the men had more pressing and profitable things to attend to; the drying of the seal skins was both laborious and precarious in the damp climate; in brief, it did not pay to bother with the fur-seals at that period. Later, however, all this was changed. The more costly furs were getting scarce and the enterprising Russian merchants, now following upon the heels of the promyshleniks, or hunters, had found a profitable market in China for large quantities of the cheaper fur-seal. Foremost among these merchants was Grigori Ivanovich Shelikof, whose name, from 1776 on to his death in 1795, was connected with the fur trade and colonization of that part of the world. He seems to have been the first to pay special attention to the skins of the fur-seal, and was for a long time the only one who gathered them in large quantities.

The discovery of the Pribylof Islands, with their countless numbers of fur-seals, did not seem to have made any difference in this. On the contrary, the increased supply seems to have created an increased demand. Under the pressure of a fierce competition a senseless slaughter of the fur-seals was carried on until the whole business was threatened with destruction, from which it was alone rescued by the formation of a dominant company, which soon swallowed up the smaller concerns and obtained a monopoly of the entire trade of the region.

By the establishment of the great Russian-American Company, in 1799, Shelikof's enterprise was merged into the larger concern, and the Commander Islands became part of what was from now on in reality a Russian colony. The supply of fur-bearing animals must have become practically exhausted on the Commander Islands by that time, for the islands were abandoned and vessels touched but seldom, scarcely one in five years. In 1826, during the second term of the Russian-American Company, a new district, the district of Atkha, was formed, consisting of the Commander Islands and the western portion of the Aleutian chain from Attu to the island of Yunaska, consequently including the Near Islands, the Rat Islands, and the Andreanof group. The agency was located on Atkha Island.

Shortly afterwards the permanent colonization of the Commander Islands was undertaken, and Aleuts and half-breeds from the Andreanof Islands and from Attu were transferred to the new settlements on Copper and Bering islands. This was accomplished before 1828, in which year Admiral Lütke, in the corvette *Seniavin*, visited the latter island and communicated with the inhabitants of the settlement at Saranna, on the north coast.[1]

Very little is known concerning the islands and the seal industry on the islands during their occupancy by the Russian-American Company. Its jealousy of both foreign and domestic interference caused it to keep all details of its dealings secret, and as the islands were entirely away from the ordinary line of travel, scarcely any outside information is to be had. The overseers were probably unimportant, possibly uneducated, persons, and the reports of the inspectors occasionally visiting the islands are probably buried in the St. Petersburg archives of the company.

There can be no doubt that the alarming decrease in the Pribylof catch, which in ten years dropped from 60,000 skins to less than 20,000, caused the company to colonize the Commander Islands in order to work the seal rookeries there. In 1821 this decrease was threatening enough to make the board of administration of the company suggest stopping killing on the Pribylofs altogether for one season, if certain islands which were supposed to exist north of the Pribylof Islands should be found to be fictitious or not to harbor the hoped-for fur-seals (Fur Seal Arb., VIII, p. 323). The discovery was evidently not made, and the reoccupation of the Commander Islands resulted.

It seems, however, that the Greek war of independence against Turkey had a depressing effect on the fur market of Europe, and it is therefore not improbable that the Pribylof Islands were capable of filling the demand until the restoration of order in that part of the world, about 1830. By this time the annual yield of the Pribylofs had fallen to 16,000, and shortly after even as low as 6,000, the average during the ten years from 1832 to 1841, inclusive, being less than 9,700 skins a year. As I have shown elsewhere, this was not nearly enough to satisfy the demand, which probably averaged in the neighborhood of 25,000 during this period, and the deficiency was probably made up in the Commander Islands.

With the destructive methods then in vogue, it is not to be wondered at if the Commander Islands were unable to furnish an annual quota of, say, 14,000 skins for any considerable length of time. The close season which Chief Manager Etholin asked for and probably instituted in 1843 was therefore very necessary. From this

[1] This fact shows that Dybowski's statement that the settlements were not established until 1830 (Wyspy Komand., p. 36) is erroneous.

time until the end of the régime of the Russian-American Company the yield of the Commander Islands was very insignificant. It is true, the reports were in 1859 that the rookeries were again crowded, a condition evidently due to the improved methods, especially the prohibition of killing the females, but as the Pribylof Islands showed the same favorable conditions and could easily supply the demand, there was no inducement for the chief management in Sitka to incur the increased labor and risk at the more distant islands, and it is probable that the Commander Islands were only worked enough to supply the kind and quantity of skins demanded for the Siberian (Kiakhta) trade, a comparatively insignificant amount (5,000 to 6,000 a year).

In a general way the condition of affairs on the Commander Islands during this period must have been very similar to that on the Pribylofs, though from their remoteness from the seat of the general management and their comparative insignificance the criticisms of the company's dealings which were current probably applied with still greater force to the Commander Islands.

Once a year the islands had communication with the outer world. A small vessel brought supplies, etc., from Sitka and carried away the dried skins.[1] In the earlier days, after the recolonization of the islands, the skins were apparently shipped to one of the ports in the Okhotsk Sea, but this was changed later, so that all the furs were first sent to Sitka, whence they were reshipped the following year. This method, however, involving additional cost and risk, was discontinued in 1854, and the vessel which brought the supplies and inspectors was henceforth ordered to proceed with the skins to Ayan, on the Okhotsk Sea, by way of the Kuril district (Fur Seal Arb., VIII, p. 349). Occasionally some of the vessels of the semi-military navy of the company would call at the islands on their cruises of protection against the foreign—chiefly American—fleets of whale ships which infested the waters in those days, and even landed on and raided the islands.[2]

When finally, in 1868, the Russian-American Company abandoned the management of the islands, the so-called "interregnum" commenced. The islands were placed under the jurisdiction of the Petropaulski district, and the first thing the ispravnik, or official, of that place did was to issue a proclamation declaring the natives to be free men[3] and giving them liberty and power to regulate all their affairs, including the catch of the fur-bearing animals. It seems that only a non-commissioned officer, Teterin, was left in charge.

Quite a number of foreign merchants, among them the Russian vice-consul at Honolulu, Mr. Pfluger, but mostly American citizens, prominent among whom was the so-called "Ice Company" of San Francisco, flocked to the islands, their schooners bringing all sorts of trade goods, necessities and luxuries of life—particularly the latter—

[1] I am not aware that skins were ever salted on the Commander Islands during the time of the Russian-American Company.

[2] Note, for instance, the case told by Tikhmenief (Istor. Oboz. Ross. Amer. Komp., II, p. 131?) to the effect that "in 1847 one of the whalers came to Bering Island, and on the captain being told that he must not capture sea-lions on a neighboring small island [evidently Ari-Kamen], he ordered the overseer of the island to be turned off his ship, and immediately went on shore with his men with the evident intention of disregarding the prohibition. It was only when active steps were taken to resist them that the whalers left, but before going they cut down a plantation, which had been grown with great trouble, the island being without other trees or shrubs." It is curious to reflect that the British case at the Paris Tribunal has taken this incident as a proof that "traffic in fur-seal skins was carried on by a United States whaler at Bering Island" (Fur Seal Arb., IV, p. 66). There never were fur-seals on the island referred to, though, on the contrary, it formerly abounded in sea-lions (sivutch), the only animal mentioned by Tikhmenief.

[3] During the régime of the Russian-American Company the natives were practically serfs.

and, not to be forgotten, plenty of alcohol. In return they brought away as many pelts as they could induce the natives to secure. The rivalry between the traders was very sharp and the natives had high carnival most of the time as a consequence. Gambling and drinking prevailed to a fearful extent, and the natives were willing to sell anything and everything for whisky. The drunken debauches were carried on right on the rookeries, and it is authoritatively stated that, as the skins of the female seals were higher priced, because of their finer fur, quite a number of this class were slain. Besides, drunken men would not be very apt to discriminate as nicely as necessary to distinguish the females from the bachelors. It is also authoritatively asserted that a count of the skins taken was never kept, neither by the natives nor by the police authorities in Petropaulski. The figures presented elsewhere, giving the total export of skins for the period as from 60,000 to 65,000, are, therefore, only guesses and are probably underestimated rather than overestimated. At least one of the vessels, with its valuable cargo of furs, was lost. As a result of this reckless slaughter the rookeries were nearly ruined in those three years.

In 1871 there was a wholesome awakening. Hutchinson, Kohl & Co., a San Francisco firm which had already acquired extensive property and trading rights in Alaska, had opened negotiations with the authorities at St. Petersburg for a lease of the islands on practically the same conditions upon which the Alaska Commercial Company leased the Pribylof Islands of the United States, and the contract was signed February 18, 1871, but was kept a profound secret until the following summer. In the meantime the Ice Company, ignorant of the lease and in anticipation of a profitable season, had dispatched a large cargo of merchandise to the islands. Shortly after the representative of the new company arrived with the lease and took possession. As the lease not only included the monopoly of taking the furs but also of trading with the natives, there was no other choice for the Ice Company but to sell out to its successful rival at a ruinous price. So well had the secret been kept that even the ispravnik at Petropaulski, who was still to retain jurisdiction over the islands, did not know of the lease and the impending change until it was presented to him by the company's representative alluded to.

With the taking of possession by the new company a new order of things commenced. The firm's name was altered to Hutchinson, Kohl, Philippeus & Co. It had been necessary, in order to obtain the lease from the Russian authorities, to include at least one Russian subject in the firm, and Mr. Philippeus, a Russian merchant having great trading interests in Kamchatka and neighboring districts, was paid a considerable amount for the use of his name in this connection. Nominally, therefore, the company was Russian, but practically it was American. Their vessels were flying the Russian flag, but they were American property. In 1872 Hutchinson, Kohl & Co. sold their interest and property in Alaska to the Alaska Commercial Company of San Francisco, members of which also acquired a controlling interest in the Russian company. From that time on until the expiration of the lease in February, 1891, the management of the company's affairs on the Commander Islands and Tinleni Island were in the hands of the celebrated firm, with headquarters at 310 Sansome Street, San Francisco.

The management now became practically identical with that on the Pribylofs, and an employee from the latter was sent over to the Commander Islands to teach the natives the improved methods of taking the seals and curing the skins adopted

on the former. It is, therefore, unnecessary to go into details concerning this part of the industry, which has been described so often in connection with the Pribylof Islands.

The affairs as I found them in 1882 were managed in the following way:

On each island there was a local agent and storekeeper,[1] who had general charge of affairs, except the management of the taking of the skins, and who kept the books and accounts. The sealing business proper was attended to by a sealer for each rookery, who accepted the skins brought by the natives to the salt-house door and superintended the salting, bundling, etc. During this period these overseers were not natives, except Mr. Fedor Volokitin, a "creole," who represented the company at the South Rookery, Bering Island. The general management of the business was in the hands of Mr. John Sandman, the captain of the company's steamer *Aleksander II.*

Practically, the whole administration of the business rested with the company, not even a maximum limit as to the number of skins to be taken being contained in the lease. The function of the Government official stationed on the islands was chiefly confined to seeing that the company did not overstep its contract, that the regulations for the protection of the seals, as well as the natives, were enforced, to supervise the killing, keep account of the number of skins taken, to receive and distribute the money for the skins to the natives, etc.

The skins were taken by the company's steamer from the islands to Petropaulski in installments and there reloaded before shipment to San Francisco. One of the reasons for this arrangement was that Petropaulski is the only port of entry in that part of the Russian Empire, and as the skins were to be shipped to San Francisco, a foreign port, clearance paper had to be obtained in Petropaulski, while at the same time the insurance companies would only assume the risk from the sailing from the latter port. At this place, therefore, Hutchinson, Kohl, Philippeus & Co. maintained quite an extensive establishment. Large warehouses and a wharf were built on the spit in the outer harbor near the extreme end of the Nikolski peninsula, while in the town itself a large and commodious house for the accommodation of the resident agent and his family was erected.

This position as resident general agent in Petropaulski was held to the expiration of the term of Hutchinson, Kohl, Philippeus & Co. by Mr. Joseph Lugebil, who extended the company's hospitality in a manner pleasantly remembered by all who had the good fortune to visit Petropaulski during that period.

Under the lease the company was to keep a general store for the sale of articles of food, clothing, etc., to the natives on each of the Commander Islands. The merchandise was imported free of duty, but the company was only allowed to charge San Francisco wholesale prices plus a certain fixed percentage as compensation for freighting and storing the goods. The company decided about the kind and quantity of goods to be brought, while the administrator appointed by the government saw to it that the prices charged were not in excess of the contract and that the quality of the goods was satisfactory.

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[1] On *Copper Island:* Mr. Alexander Kostromitinof, who succeeded Mr. C. F. Emil Krebs. The latter served from 1871 to 1881. Mr. Emil Kluge followed after Mr. Kostromitinof until the fall of 1894, when he was succeeded by Mr. A. Cantor.

On *Bering Island:* Mr. George Chernick. He died on the island in the fall of 1887, Mr. F. Volokitin tending the station during the following winter. In the spring of 1888 Mr. Kostromitinof was transferred from Copper Island, being relieved in 1890 by Mr. Julius Lindquist. He was succeeded in about a year by Mr. Waldemar Paetz, of St. Petersburg, whose term expired in 1895, Mr. Emil Kluge being then transferred from Copper Island.

The original lease stipulated a price of 2 silver rubles ($1.33) per skin accepted by the company, but in a subsequent supplementary contract the tax, from 1877 on, was reduced to 1.75 rubles ($1.17) for the first 30,000 skins. The natives received for their work 1 ruble (66⅔ cents) per skin for the first 30,000, and one-half ruble (33⅓ cents) for each skin over 30,000. The company had to pay a yearly rental of 5,000 rubles, and to contribute a considerable amount toward the support of the natives.[1]

There being no serviceable buildings left by the old company, Hutchinson, Kohl, Philippeus & Co. had to build a number of houses on both islands to accommodate their goods and their men. Salt-houses were erected on all the rookeries, and near each a small frame-hut for occupancy by the company's "sealer" during the killing season. In the main village on Bering Island several large stores and warehouses, a cow-stable, boat-house, bath-house, besides two dwelling-houses were built, as well as similar though somewhat smaller structures in the main village on Copper Island. These are all frame-houses built of California or Puget Sound lumber by an American head carpenter with the assistance of native workingmen.

Although under no legal obligation to do so, the company gradually built and presented to nearly all the families on both islands commodious frame-houses, mostly with 4 rooms, similarly built, the natives receiving full title to them.

By careful management the seal rookeries, which at the beginning of the company's term scarcely yielded 30,000 skins annually, toward the end produced about 50,000 a year, the annual average between 1880 and 1889 being nearly 45,000. Among the entries in the diaries of the company's agents during this period are many like the following: "Natives say there are a good many female seals this year, and holostiaks, too" (Bering Island, July 23, 1877). "Assistant Starshena (chief) has been on South Rookery; reports that both holostiaks and females are double in quantity as has been before, but not many old bulls. On the North Rookery there are more seals, too" (Bering Island, August 12, 1877). "Natives report good many thousand seals more this year than ever before" (Bering Island, August 2, 1880).

The lease of Hutchinson, Kohl, Philippeus & Co. expired in February, 1891, and as the new lease was awarded to a new company, the old company's steamer *Aleksander II* was sent, early in the year to take off the fall catch of 1890, consisting of 5,800 skins.

The new company, into the hands of which the sealing industry of the Commander Islands and Tiuleni now passed, was incorporated in St. Petersburg under the name "Russkoye Tovarishtchestvo Kotikovikh Promislof,"[2] or the "Russian Seal Skin Company," as the name of the firm is officially rendered in English.

By the new contract the mutual relationship of the government, the natives, and the company was materially changed, considerable power being placed in the hands of the administrator, while the direct dealings of the company with the natives were greatly reduced. The gradual americanization of the natives under the régime of Hutchinson, Kohl, Philippeus & Co. was undoubtedly distasteful to at least one of the inspectors, whose opinion with the St. Petersburg authorities must have been of great weight, as there is now a manifest tendency toward a rerussification of the business and its methods.

[1]The text of the contract, with supplement, is printed in Sbornik Glavn. Off. Dokum. Upravl. Vost. Sibir., III, ii, Append., pp. 1-8.

[2]Russian Company for Fur-Seal Hunting (lit. transl.).

The tax to be paid for skins was raised considerably. Under the present contract the company pays to the Russian Government 10.38 "metallic" rubles (gold) per skin taken, one-half to be paid in St. Petersburg in the month of May, in advance of the sealing season. This advance payment, from 1891 to 1894, was made on a basis of 50,000 skins to be taken. In the meantime Russia had agreed with England not to take more than 30,000 skins a year, hence from 1895 the advance payment was made on a basis of only 30,000 skins. The other half is paid at the end of the season, when the amount of the catch is known. The amount which the Russian Government pays the natives for their work, 1.50 rubles per skin, is usually paid at the islands by the company at the end of the season and deducted from the draft of the balance due in St. Petersburg. It will be seen that by this arrangement the Russian Government is amply protected, but in addition the company is obliged to deposit Imperial Russian bonds with the Government in St. Petersburg to an amount equaling that of the advance payment.

The entire sealing business is exclusively in the hands of the local administration, and the company has nothing further to do with it but to receive the skins at the side of the vessel, except that it accepts or rejects the skins immediately upon their being brought from the killing-grounds and superintends the salting of the skins, for which purpose it also furnishes the salt. The administrator, therefore, has unlimited power to determine how many seals are to be taken, and also how, when, where, and by whom they are to be taken. The Government undertakes the driving, killing, skinning, salting, bundling, and delivery. The administration takes the temporary receipt for the skins issued by the company's overseer at the salt-houses and finally the agent's receipt when the skins are received on board the company's vessel. The skins are then brought to Petropaulski, where the ispravnik can not give clearance papers without first receiving the certificate of the administrator of the islands that the company has complied with the Government requirements.

Like Hutchinson, Kohl, Philippeus & Co., whose establishments both on the islands and in Petropaulski the Russian Seal Skin Company acquired, the latter has the exclusive right to keep a store on each island in which to sell to the natives such staples and articles as are necessary for their existence and comfort. The company is not allowed to bring such articles as it may deem thus necessary, but the administrator each year makes out a detailed list of quantities and qualities, specified in the minutest details, which goods the company, upon his requisition, are obliged to bring during the year and to sell to the natives at a certain stipulated percentage over the certified market price, the Government showing a decided preference for Russian goods. Should any of the goods thus ordered remain unsold on the company's hands the loss falls upon the company. As a rule, the company sells for cash to the natives, unless the administrator expressly authorizes a family head to take goods on credit, in which individual case the amount is specifically limited. At the first distribution of money for work or furs the amount is paid and the debt canceled before new sales can be made.

For the privilege of thus trading the company has to pay all the various license and guild fees to which the Russian merchants are liable, in this case amounting to many hundred rubles.

STATISTICS.

Having thus given a brief résumé of the history of the fur-seal industry on the Russian side, as it is revealed in the scanty records, it may be well to present, in chronological order, such statistics as I have been able to bring together showing the number of fur-seals taken at various times on the Commander Islands. Unfortunately, many of the figures submitted are only hypothetical, some even highly problematical, but I have accompanied them with a running comment which it is hoped is sufficiently explicit to show how the estimates were made.

It is not probable that any great slaughter of the fur-seals took place during the first period. Bassof and Trapeznikof returned from the Commander Islands in 1746 with a cargo of furs, among which are mentioned 2,000 fur-seals (Bancroft, Works, XXXIII, p. 100), but in the returns of the other expeditions between 1743 and 1750 no other mention of seal skins is made. As sea-otters and blue foxes are mentioned frequently, it is evident that the fur-seal skins were of but little importance and value. It is also probable that in those days only the pups were taken, for it is specifically stated that Yugof's cargo of fur-seals, when the vessel returned in 1754 from Copper Island, consisted of 1,765 black pups and 447 gray ones (Neue Nachr. Neuent. Ins., 1776, p. 22). Tolstykh, likewise, in 1750 returned from Bering Island with 840 "young fur-seal skins or *kotiki*" (*ibid.*, p. 26), and Vorobief in 1752 is said to have brought to Kamchatka, probably from the Commander Islands, "5,700 black and 1,310 gray young fur-seals or *kotiki*" (*ibid.*, p. 27). Drushinin in 1755 returned with 2,500 seals taken on Bering Island (*ibid.*, p. 32). These, as well as the 2,000 brought by the *Vladimir* in 1767 and the 630 in Popof's *Ioann Pretecha* in 1772, were also probably young.

As I have shown elsewhere (Amer. Natural., XXI, Dec., 1887, p. 1053), the sea-cow on the Commander Islands had become nearly extinct in 1763. The sea-otter had also been killed off there to such an extent that the hunt had become unprofitable, and the blue foxes likewise. As the fur-seal skins were of comparatively little value, there were no inducements for the fur-hunters to visit the islands after that time as frequently as before. It is certain enough, as shown above, that the fur-seals had not left the Commander Islands, or become nearly extinct there, as alleged by Elliott, as there are records of vessels having actually visited the islands between 1760 and 1786, bringing plenty of seal skins back. As a matter of fact, it was during this very period that the heaviest slaughter of fur-seals took place on the Commander Islands. It appears that Shelikof was the first trader to deal extensively in fur-seals, and his name is not mentioned until 1776. It is stated that up to 1780, consequently in four years, he had imported 70,000 fur-seal skins. It is furthermore stated that his vessel, *Sv. Ioann Rylskoi*, returned in 1786 with 18,000 fur-seals. In the same year Protassof returned with a "cargo consisting chiefly of fur-seals." Panof's vessel, *Sv. Georgi*, which also returned in 1786, had less luck, having secured only 1,000 seal skins. As the Pribylof Islands were not discovered until that year (the first cargo from there did not arrive in Okhotsk until 1789), the bulk of the fur-seal skins brought to Kamchatka must have come from Commander Islands (see Bancroft, Works, XXXIII, pp. 185–191). There is *record* of about 100,000 skins having been taken between 1760 and 1786, while from 1746 to 1760 the skins brought to Kamchatka probably did not exceed 20,000.

For the early times, between the return of the first cargo from the Pribylof Islands to 1841, the year of the expiration of the second term of the Russian-American Company, there are absolutely no accessible records as to the number of seals taken at

or shipped from the Commander Islands. Elliott states (Monogr. Pribyl. Group, p. 70) that from 1797 to 1861 the statistics of skins taken from the Pribylof Islands include "about 5,000 annually from the Commander Islands," but I have reasons for believing that this statement is erroneous. As I have shown elsewhere, there was no regular population on the Commander Islands until after 1826, and as vessels touched at the islands at great intervals only, an annual catch of 5,000 skins from the Commander Islands is out of the question. This is also plain from the figures given by Veniaminof and Von Wrangell. The former, according to the table presented by the British Bering Sea commissioners (Rep., p. 132), gives the total number of seals killed on the Pribylof Islands from 1826 to 1832, inclusive, as 137,503. This agrees fairly well with the statement by Baron von Wrangell, the chief manager of the Russian-American Company during that period, that the total number of skins exported from the colonies from 1827 to 1833 amounted to 132,160. This number is clearly meant to include all the skins exported from the whole colony, and would include any and all from the Commander Islands, if skins were then taken there, for he expressly remarks that his statistical figures date from the incorporation of the Atkha district, which included the Commander Islands, under the colonial management (Stat. Ethn. Nachr. Russ. Besitz. Nordwestk. Amer., p. 24).

The fact that the Commander Islands were not subject to the central management located at Sitka until 1826 leads me to believe that the few Commander Islands skins taken are not reported in the figures before that date, but that they were received direct either at Petropaulski or Okhotsk.[1]

But even Veniaminof's figures are not beyond suspicion. In his "Zapiski," published in St. Petersburg in 1840, vol. I, chap. XII, he writes as follows (according to Elliott, Monogr., p. 165): "The company on the island of St. Paul killed from 60,000 to 80,000 fur-seals per annum, but in the last time (1833?) [Elliott's interpolation], with all possible care in getting them, they took only 12,000. On the island of St. George, instead of getting 40,000 or 35,000, only 1,300 were killed." Now, if we examine the table of his figures, as presented by Elliott (Monogr., p. 143), we find no year between 1817 and 1837 in which 12,000 seals were taken on St. Paul (13,200 in 1833), nor 1,300 on St. George.

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[1] To show how very unsatisfactory the statistical figures of the early days as collated by the British Bering Sea Commission are, I may mention that they estimate the number of fur-seals killed on the Pribylof Islands from 1786 to 1833, inclusive, as follows:

1786 (according to Shelikof)	40,000
1787-1806 (Rezanof's estimate)	1,000,000
1807-1816 (approximated from Tikhmenief at 47,500 annually)	475,000
1817-1833 (Veniaminof)	543,239
Total, 1786-1833	2,058,239

This number is 1,120,323 skins short, for Baron von Wrangell, who undoubtedly had pretty reliable information to go by, states that "since the discovery of the islands St. Paul and St. George, from the year 1786 to 1833, 3,178,562 fur-seals were killed *there*" (Stat. Ethn. Nachr. Russ. Am., p. 48). These I should be inclined to distribute as follows:

Fur-seals killed on St. Paul Island, 1786-1833:	
1786 (according to Shelikof)	40,000
1787-1798	1,095,467
1799-1816 (Bancroft's figures from 1799-1821, 1,767,340, minus Veniaminof's figures from 1817-1821, 267,484)	1,499,856
1817-1833 (Veniaminof)	543,239
Total (= Von Wrangell's figure)	3,178,562

In the same table and report it is stated (p. 133) how the figures for the years 1861 and 1862 are obtained: "1861.—Bancroft's total for years 1842-1861 (both inclusive) is 338,600. The total for years 1842-1860 (both inclusive) is 308,901. This being deducted from total for 1842-1861 gives the number of seals taken in 1861." In their table, however, the total for 1842-1860 is not 308,901 but 318,901.

While thus the figures relating to the Pribylof Islands are dubious and unsatisfactory, there are next to no records in regard to the catch on the Commander Islands between 1787 and 1862. In fact, there is hardly a scrap of available history to be found on the subject during that period.

There is no reason to doubt, however, that the slaughter of the fur-seals on the Commander Islands after 1787 was as enormous as on the Pribylofs, proportionately (where, according to my calculation, the average annual killing was 86,511.)[1] The result of this *indiscriminate* wholesale slaughter undoubtedly brought the rookeries to a very low ebb, for we find the Commander Islands practically abandoned shortly after the establishment of the Russian-American Company, and a permanent population was not again established until after 1826, by which time the rookeries must have recuperated to some extent. The same old method of killing the young ones, and not even sparing the females, must soon have brought on the inevitable result of depletion, for we find that the chief manager of the colonies, Capt. I. A. Kuprianof, as early as 1839, had conferred with the baidar-steerer Shayashnikof as to when, in his opinion, it would be possible to begin taking a full catch on St. Paul Island in order to *establish a close time for sealing on* St. George and *the Commander Islands*, and that Captain Etholin, his successor as chief manager, in 1842 asked permission to institute a close season on the Commander Islands, a permission that was granted the following year (Fur Seal Arb., XVI, pp. 76, 114).[2]

Shortly after, the prohibition to kill females was enforced, and as a result of both measures the seals were again increasing, so that in 1859 the chief manager could write to St. Petersburg that, according to the reports of the officials of "even those of the Commander Islands, the seals have increased in numbers on all accessible places to such an extent that the areas occupied by them appear crowded." It is evident, however, that the managers proceeded with caution, notwithstanding, for in the years from 1862 to 1867, the year of the final dissolution of the Russian-American Company, only 4,000 to 5,000 seals (gray pups) a year are said to have been taken. These figures are from the following table, which is copied from the report of the British Bering Sea commissioners (p. 214), those from 1865 being official:

Skins taken for shipment from Commander Islands, 1862–1867, by the Russian-American Company after the expiration of its third term.

Notes.	Year.	Number.
Only gray pups killed	1862	4,000
Do	1863	4,500
Do	1864	5,000
Do	1865	4,000
Do	1866	4,000
Do	1867	4,000
Total		[3]25,500

[1] Not only were females and pups killed, but the "bulls and young bulls" also, for in spite of their coarse hair the Chinese at Kiakhta paid high prices for them (Fur Seal Arb., VII, p. 165).

[2] Figures representing the catch during the Russian-American Company's terms are given in the final table of shipments by periods.

[3] In Nordenskiöld's "Voyage of the Vega," Am. ed., p. 609, there is a table of figures relating to the catch of seals on the Commander Islands involving several errors. Aside from the fact that it purports to give the catch on Bering Island only, while in reality the figures represent the catch on both Bering and Copper islands, it gives the catch for the year 1867 as 27,500 seals. Here is apparently a double error. Compared with the corrected figures given by Elliott (Monogr., p. 113), 27,500 is evidently meant to include the catch from 1862 to 1867, inclusive, in which case, however, the statement is 2,000 too high.

The table of the British commissioners in the note says "including Robben Island," but no skins were regularly taken there in those days.

During the so-called "interregnum"—that is, the years 1868–1870, inclusive—from the time the Russian-American Company abandoned the management of the islands until Hutchinson, Kohl, Philippeus & Co. assumed control, no restrictions, except such as the natives themselves might impose and enforce, were placed upon the slaughter, which in these three years averaged about 20,000 annually. The seals taken up to that time were exclusively gray pups, but during the interregnum at least one of the traders, viz, Mr. J. Malovanski, had become aware of the increased demand and higher prices for bachelor seals, and he consequently induced the natives to bring him skins of the latter. However, of the 60,000 killed a great many must have been young ones, but the proportion between the two classes will probably never be known. Three sets of figures are given for the catch in these three years, as follows:

Year.	Elliott (Monograph, p. 113).	Niebaum (Fur Seal Arbitration, III, p. 202).	British Bering Sea Commissioners (Rep., p. 214).
	Number.	*Number.*	*Number.*
1868	12,000	* 15,000	12,000
1869	24,000	20,000	21,000
1870	24,000	30,000	27,500
Total	60,000	65,000	60,500

* About.

It is doubtful whether any of these figures are exact, but as they agree pretty well, and as the last set represents the official figures of the Russian administrator, they may be taken as authentic.[1]

Upon the arrival on the scene of the agents of Hutchinson, Kohl, Philippeus & Co., in 1871, it was found that the *indiscriminate* slaughter during these three years had again done sensible injury to the rookeries. Says Mr. C. F. Emil Krebs, who stayed on Copper Island from 1871 to 1881 (Fur Seal Arb., III, p. 195):

> Upon my arrival at the island, in 1871, the native chief told me that the seals were not as plentiful as they had been formerly. I announced that we intended to secure 6,000 skins that year. They protested that it was too many, and begged that a smaller number be killed for one year at least. We, however, got the 6,000 skins, as proposed,[2] and an almost constantly increasing number in every subsequent year as long as I stayed on the islands, until in 1880 the rookeries had so developed that about 30,000 skins were taken, without in the least injuring them.

The history of the gradual increase of the yield of the rookeries during the following twenty years, and the subsequent decrease until the present day, is plainly shown in the following tables. It should be remarked that the lower figures of 1876, 1877, and 1883 are due not to a lack of seals on the rookeries, but to the fact that the company did not desire more (in 1883, in fact, not as many as they were obliged to take). The following comparison of the Commander Islands and Tiuleni catches with those of the Pribylof Islands demonstrates the correctness of this statement.

[1] I may here correct a mistake in the oft-mentioned table presented by the British Bering Sea commissioners (Rep., p. 214). They run a line between the years 1869 and 1870 and mark it "Alaska Commercial Company's first term began." As a matter of fact the term (and *only* term) of Hutchinson, Kohl, Philippeus & Co., the term and company meant, did not begin until 1871, and the catch of 27,500 skins during 1870 is therefore to be credited to the merchants trading during the interregnum.

[2] Only 3,614 of that number were shipped in 1871, the remainder in 1872.

Comparison of the catches at Commander Islands and Tiuleni with those at Pribylof Islands.

Year.	Commander Islands and Tiuleni.	Pribylof Islands.	Year.	Commander Islands and Tiuleni.	Pribylof Islands.
	Skins.	*Skins.*		*Skins.*	*Skins.*
1874	31, 300	107, 932	1880	48, 504	100, 634
1875	36, 279	101, 249	1881	43, 522	101, 734
1876	26, 960	89, 478	1882	44, 620	101, 736
1877	21, 533	77, 956	1883	28, 699	77, 063
1878	31, 340	101, 394	1884	53, 263	101, 013
1879	42, 740	106, 908			

There are a number of published statements referring to the seal catch on the Commander Islands since 1871, but none of them are complete, nor are the figures given for the separate islands. The figures also vary to some extent, for several reasons. In some cases the Tiuleni Island skins have been counted in with those of the Commander Islands. Thus, in Capt. G. Niebaum's statement (Fur Seal Arb., III, p. 204), by inadvertence the number of killed seals for 1890, 53,780, includes 1,456 skins from Tiuleni, the total for the Commander Islands being only 52,324. Many other discrepancies are explained by the fact that the various figures refer to various counts. Some may and do refer to skins shipped, others to seals killed. The almost unavoidable difference in the counting of such large quantities of skins is manifest when we remember that the skins are first counted at the salt-house and then again as they go over the ship's side into the hull. Upon these counts the official government statement is made up. The skins are then unloaded in Petropaulski, again loaded into the steamer, and again unloaded and counted in San Francisco. It is, therefore, not to be expected that lists made up from the various figures in the island count, the ship's count, and the custom-house count would agree exactly. The figures given in the following table are based chiefly upon the various station journals as well as the ships' logs, partly upon the figures already published, and partly upon a list showing the number of seals shipped between 1883 and 1891 from Bering and Copper islands separately, kindly furnished by Mr. Max Heilbronner, of the Alaska Commercial Company.

Number of fur-seal skins shipped from Commander Islands and Robben Island from 1871 to 1895, inclusive.

Year.	Bering Island.	Copper Island.	Robben Island.	Total.	Year.	Bering Island.	Copper Island.	Robben Island.	Total.
1871	0	3, 658	0	3, 658	1885	20, 966	20. 771	1, 838	43, 575
1872	14, 392	14, 964	0	29. 356	1886	24, 555	30, 036	0	54, 591
1873	13, 044	14, 661	2, 694	30. 399	1887	21, 298	25, 049	0	46, 347
1874	13, 406	15, 480	2, 414	31, 300	1888	26, 456	20, 906	0	47, 362
1875	12, 712	20, 440	3, 127	36, 279	1889	23, 783	29, 076	0	52, 859
1876	10, 358	15, 074	1, 528	26, 960	1890	19, 996	32, 328	1, 456	53, 780
1877	7, 192	11, 392	2, 949	21, 533	1891	*17, 884	†18, 065	450	36, 815
1878	8, 130	20, 070	3, 140	31. 340	1892	16, 590	14, 654	0	31, 244
1879	13, 572	25, 166	4, 002	42, 740	1893	13, 992	17, 294	1, 500	32, 786
1880	15, 160	30, 014	3, 330	48. 504	1894	13, 165	13, 122	1, 000	27, 287
1881	16, 078	23, 237	4, 207	43, 522	1895	9. 526	6, 893	1, 300	17 719
1882	18, 512	22, 002	4, 106	44, 620					
1883	13, 480	13, 170	2, 049	28, 699	Total	385, 631	485, 582	44, 909	916, 122
1884	21, 384	28, 060	3, 819	53, 263					

* Of these, Hutchinson, Kohl, Philippeus & Co. shipped 4,059; the Russian Seal Skin Co. shipped 13,825.
† Of these, Hutchinson, Kohl, Philippeus & Co. shipped 1 741; the Russian Seal Skin Co. shipped 16,324.

To this total should be added 416 skins taken from the schooner *J. H. Lewis*, seized in 1891, and 2,152 skins taken in 1892 from the seized schooners, which obtained them chiefly off Copper Island. The latter skins were sold by the Russian Govern-

ment, part in Petropaulski (1,124), part in London, and were shipped in the company's steamer to San Francisco (see Fur Seal Arb., VII, pp. 375, 417). The total number of skins shipped from the Russian seal islands from 1871 to 1895, inclusive, is, therefore, 918,690.

That this list does not give an accurate idea of the number of seals killed in each particular year is clear from the fact that the fall catch of the year is not shipped until the following summer. In some years there was no fall catch at all, in others it was very considerable. Thus, for instance, in 1871, the first year of the lease of Hutchinson, Kohl, Philippens & Co., no less than 10,500 seals were killed on both islands, of which, however, only 3,658 were shipped from Copper Island (the island count, or 3,614 by the San Francisco count), while none at all were shipped from Bering Island. Full data of the actual number of seals killed in each year are not at hand, but the following table, based upon data furnished me by the late Mr. G. Chernick, then station-keeper on Bering Island, may serve as an indication of the difference between a list of seals killed and one of skins shipped.

Seals killed and skins shipped from Bering Island, 1871–1882.

Killed.				Shipped.	
Year.	Total.	Summer.	Fall.	Skins.	Year.
1871	4,500	....	....	14,392	1872
1872	12,912	9,892	3,020	13,044	1873
1873	13,040	10,024	3,016	13,406	1874
1874	13,034	10,390	2,644	12,712	1875
1875	11,790	10,068	1,722	10,358	1876
1876	9,822	8,636	1,186	7,192	1877
1877	6,006	6,006	....		
1878	8,674	8,130	544	8,130	1878
1879	13,028	13,028	....	13,572	1879
1880	15,160	15,160	....	15,160	1880
1881	16,078	16,078	....	16,078	1881
1882	18,512	18,512	....	18,512	1882

It would have been interesting and instructive to have a list of skins taken from each rookery for a considerable length of time, but I have been unable to obtain the necessary data. The following table, however, furnishes this information for the years 1891 to 1895:

Fur-seals killed on the Commander Islands, 1891–1895.

Locality and season.	1891.	1892.	1893.	1894.	1895.
Bering Island:					
Summer—					
North Rookery	13,177	16,171	12,156	12,516	8,370
South Rookery	648	419	327	627	564
Fall	....	....	....	592	?
North Rookery	....	1,422	....	....	....
South Rookery	....	87	22	....	....
Copper Island:					
Summer	....	....	....	....	6,396
Karabelni	3,664	4,552	5,343	4,268	....
Glinka	12,660	10,102	10,938	8,387	....
Fall	....	....	....	497	?
Karabelni	....	451	86	....	....
Glinka	....	562	381	....	....
Total	30,149	33,766	29,253	26,887	15,330

Shipment of skins from the Commander Islands (exclusive of Robben Island), by periods.

1746 to 1760, 15 years (period of plenty of sea-otters, foxes, and sea-cows), annual average about 1,333 .... total about..	20,000
1761 to 1786, 16 years (other fur-bearing animals becoming scarce and sea-cow exterminated) annual average about 6,250 .... total about..	100,000
1787 to 1798, 12 years (from discovery of Pribylof Islands to Russian-American Company), same annual average .... total in round figures about..	50,000
1799 to 1826, 28 years (from Russian-American Company to establishment of Atkha district), annual average about 476... total in round figures about..	15,000
1827 to 1841, 15 years (to expiration of Russian-American Company's second term), yearly average about 10,000 .... or total about..	150,000
1842 to 1861, 20 years (Russian-American Company's third term), yearly average 476 .... total about..	9,526
1862 to 1867, 6 years (hold-over of Russian-American Company), yearly average 4,250 .... total about..	25,500
1868 to 1870, 3 years (interregnum), yearly average 20,166 .... total about..	60,500
1871 to 1891, 20 years (lease of Hutchinson, Kohl, Philippeus & Co.), yearly average 36,791 .... total..	735,828
1891 to 1895, 5 years (lease of Russian Seal Skin Company to date), yearly average 27,077 .... total..	135,385
Skins seized within territorial waters, 1891 and 1892	2,568
Grand total .... about..	1,304,307

As previously stated, some of these figures do not pretend to be more than guesses. Most of them are explained in the foregoing pages, but the figures for the years from 1787 to 1861 need some explanatory remarks as to how these guesses were made.

From 1787 to 1798, inclusive, 12 years, I have assumed the annual average to have equaled that of the foregoing 26 years, giving 46,152, or, in round figures, 50,000.

From 1799 to 1826, the period of 28 years during the lease of the Russian-American Company when the yield was not sufficient to induce the company to establish settlements on the islands, I have assumed that the annual average can not have exceeded the yield between 1842 and 1861, when the company still maintained the settlements, or, in round figures, 15,000.

For the 15 years from 1827 to 1841, inclusive, I have made the following guess: Assuming that Wrangell at the end of 1833 had 30,000 skins on hand, about 25,000 (Wrangell shipped, 1827–1833, 132,160 + assumed surplus on hand, 30,000=162,000—Veniaminof's figures for killed seals on Pribylofs in years 1826–1832, 137,503=24,658) must have been taken on the Commander Islands from 1827 to 1832, inclusive. In 1840 the Russians had a demand for not over 30,000 skins annually (Simpson, Overl. Journ., p. 131). Probably they were nearly able to fill it, for Mr. E. Teichmann states (Fur Seal Arb., III, p. 579) that "up to the year 1853 about 20,000 skins were annually received in London" from the Russian-American Company. It is probably safe to assume, then, that 6,000 went to Kiakhta. Now, during the nine years from 1833 to 1841, inclusive, the Pribylof Islands yielded only 80,135. The assumed sale being 234,000 skins, and there being only 30,000 on hand and 80,000 killed on the Pribylofs, it follows that a yearly average of about 14,000 would have to be obtained on the Commander Islands, or about 125,000, to which should be added the 25,000 assumed to have been taken from 1827 to 1833, giving a total of 150,000.[1]

[1] Figures thus obtained do not pretend to any accuracy. How misleading the process may be is clearly illustrated in the table presented by the British Bering Sea commissioners (Rep., p. 132) and the explanation concerning the sources of information. They utilize the total given by Bancroft for 1842–1861, viz, 338,600 (the identical figures utilized above), and from this deduct the number of skins taken from 1842 to 1860, according to a different source, thus obtaining the number taken in 1861. Correcting an apparent error in the subtractor, the number for 1861 would be 19,699. October 14, 1861, the chief manager of the colonies, Furuhielm, writes home to the board of administration that "in the course of this year 47,940 seal skins have been taken from the islands of St. Paul and St. George." 19,699 calculated, but 47,940 taken! This is a sad commentary upon the probable accuracy of the calculated figures.

The only figures relating directly to the yield of the Commander Islands during this period are those by Tikhmenief, that there were exported from Bering Island, during the third term of the Russian-American Company, 9,526 fur-seal skins (Istor. Oboz. Obraz. Ross.-Amer. Komp., II, p. 296). These figures, from the connection, are meant to cover the whole export from the Commander Islands, as from the fact that the population of Copper Island at that time was but 90, all told, it seems probable that no fur-seals were taken on Copper Island at all.

ADMINISTRATION.

There remains to be said a few words concerning the Government administration of the Commander Islands.

Before the establishment of the Russian-American Company the islands were scarcely under any territorial jurisdiction, though in reality they were undoubtedly subject to the rule of the "commander" of Kamchatka, a naval officer residing in Petropaulski. With the advent of the Russian-American Company the direct control of these islands went out of the hands of the Russian Government, but it seems that the company took but slight interest in them until 1826, in which year they were incorporated into the Atkha District, with headquarters on Atkha Island. After the permanent location of a colony, a Russian "overseer" was stationed on Bering Island.

When, in 1868, the Russian-American Company's régime was at an end, the islands returned to the jurisdiction of the "ispravnik" in Petropaulski, while the remainder of the Atkha District became part of the United States by the cession of Alaska to the latter. Kamchatka being, since 1855, only a district of the so-called Coast Province (*Primorskaya Oblast*), the administration of the islands consequently rested with the governor at Khabarovka, subject to the authority of the governor-general of Eastern Siberia at Irkutsk.

Thus things remained until the growing importance of the seal business during the lease to Hutchinson, Kohl, Philippeus & Co. made it desirable to locate a higher official on the islands to represent the Government in its dealings with the company on the islands and to govern the natives. Mr. Nikolai Aleksandrovich Grebnitski was selected as the first "administrator," landing on Bering Island on August 21, 1877, and has continued as such up to the present time. His long retention in office, coupled with the fact that his salary has been raised repeatedly, that he has gradually risen in rank, until he now holds that of a colonel, and that he has been decorated several times, is ample proof that he has conducted the affairs of the Commander Islands to the full satisfaction of his Government.

As subordinates, two kossaks from Kamchatka were stationed, one on each island. Since 1890, however, another civil officer has been located on Copper Island, acting as Mr. Grebnitski's assistant there. Until last year, when he had to seek a milder climate, on account of broken health, this position was held by Mr. Nikolai Matveyevich Tielmann. His successor was on his way to the islands in the fall of 1895, on the bark *Bering*, but on account of the weather failed to make a landing and had to return to Vladivostok.

One of the first things attempted by Mr. Grebnitski, after putting the community affairs of the natives into shape, was to regulate the fur-seal business, i. e., the administrative portion of it as it related to the taking of seals on the rookeries, and the rules first framed were embodied in an order (*prikaz*) dated April 28, 1878 (o. s.), and the second chapter of a regulation (*predpisanie*) of the following May 1 (o. s.).

In the latter a form was provided which, when filled out and signed by the overseer and native chief, is returned to the office of the administrator. Printed blanks are now furnished, and to illustrate this useful document a sample is herewith appended, as follows:

AKT.

Rookery at *Glinka, Copper Island.*
Killed in drive *June 6, 1881:*
1,053 pieces fur-seal bachelors.
2 females.
0 bulls.

Total.. *1,055* pieces.
Not accepted by the company for the following reasons:

(1)	tooth-marked	*3* pieces.
(2)	cut	*0*
(3)	undersized	*2*
	Total not accepted	*5* pieces.

Of these, the 3 tooth-marked skins were returned to the natives, the 2 undersized ones were salted.
Accepted by the company, *1,050* pieces.
Overseer, Copper Island .... *Sergeant Selivanof* (signed).
Chief, Copper Island .... *Anastas Kadin* (signed).
The receipt given by the agent is appended as a separate inclosure.

Gradually a set of elaborate regulations have been framed which govern the rookery business. Such as differ from those in vogue on the Pribylof Islands are here quoted from Lieut. Commander Z. L. Tanner's report for 1892 (Rept. U. S. Fish Com., 1892, p. 40), as follows:

None but natives are allowed to work on the rookeries.

A fine of 100 golden rubles is imposed by the Government upon anyone who kills a female fur-seal, and 10 rubles for killing a pup, and such additional fine shall be paid as shall be imposed by the natives themselves.

No person, native or otherwise, is allowed to wear boots with nails in them on the rookeries; rubber boots or tarbasi[1] must be used.

Chewing or smoking tobacco, expectorating, or attending to the requirements of nature are strictly prohibited on the rookeries.

Knives may be carried, but a stick with a metal ferule is not permitted.

No small boys or females are allowed on the rookeries, and dogs must be left half a mile from the rookeries during the breeding season.

Owing to the repeated raids on the rookeries, particularly those on Copper Island in the early eighties, by marauding schooners, which the natives in several cases had to drive off by means of powder and ball, an experiment was decided upon to station regular soldiers on the islands in order to protect them. In June, 1884, the Russian cruiser *Razboinik* brought one officer and twenty-three men for Copper Island and nine men for Bering Island. Five soldiers were stationed at the South Rookery of the latter island, where they did good service in driving off the schooner *Sakhalien* and capturing one of the crew. In a few years, however, the soldiers were withdrawn, and instead the watch force of the natives was organized in a military manner, one Kamchatkan kossak on each island and two conscript soldiers of the regulars, serving

[1] Native seal-skin moccasins.

their time, acting as officers, under the immediate command of the administrator and his assistant. Watchhouses are erected overlooking the rookeries, and the guards provided with good spyglasses and rapid-firing army rifles. Stands of arms and plenty of ammunition are kept in the Government building at the settlements.

The central authorities maintain the supervision of the local administration by occasionally sending out an inspector, or "revisor," as he is called. His duty is to ascertain the state of affairs generally, as well as the condition of the natives, to receive any complaints of the latter, and investigate their grievances.

A change has of late years been effected in the higher administration of the islands, inasmuch as they have been transferred from the Department of the Interior to the Department of the Imperial Domains, without prejudice, however, to the territorial jurisdiction of the governor-general of the Amur Provinces. The administrative status of the Commander Islands is therefore now exactly parallel to that of the Pribylof Islands in their double relation to the United States Treasury and the governor of the Territory of Alaska.

CONDITION OF THE COMMANDER ISLANDS ROOKERIES.

PRELIMINARY REMARKS.

When, in 1882, Prof. S. F. Baird sent me to the Commander Islands to study their natural history he also impressed upon me the desirability of obtaining some information in regard to the fur-seal and the sealing industry of the islands. Owing to my hurried departure—I had only 48 hours in which to prepare for the expedition destined to stay two years in the field—I failed to take a photographic outfit with me. In default of photographs, however, I made numerous sketches of the rookeries, and also undertook to construct maps of them by means of an azimuth compass and a pediometer. I submit some of the sketches with this report in exact facsimile of the originals; they have not been touched up in any manner (pls. 20, 41, 42, 43). For that reason they appear extremely crude, but it is thought that they will be accepted with more confidence in their present shape and carry with them more conviction than if they had been fixed up or "improved" in any way.

The only photographs of the rookeries in their palmy days were taken by the Russian Colonel Voloshinof, but with only a few exceptions they are not intended to portray the totality of seal life on the individual rookeries, and for that reason offer but scant material for comparison with my sketches of 1882–83, or my photographs of 1895, the more so since the points of view in all instances except one are different from mine. However, those that can be utilized in this connection I have reproduced.

When photographing the rookeries last summer I made a special effort to obtain views from the identical points from which I had made my sketches in 1882 and 1883. Taking into account the different focus of the eye and the photographic lens, I think a comparison between the sketches and the photographs will establish the general accuracy and truthfulness of the former.

When studying the rookeries in 1882–83, I did it with H. W. Elliott's Monograph of the Pribylof group in my hands. In the main I found that his observations in regard to seal life were applicable to the Commander Islands seals, and at the same time that the conditions of the sealing industry were also nearly the same on the two groups, so far as could be judged from descriptions alone. There were minor points

in which I found, or thought I found, differences, but in the main I agreed, with one notable exception, however, viz, the estimation of the number of seals on the rookeries. Of course, his estimate related only to the Pribylof group, and as I knew the latter only from his description, I felt bound not to criticise him. But I became sure of this: His methods and results did not apply to the Commander Islands. Elliott's method was to ascertain the area of the rookeries in square feet and then multiply this with an average figure calculated from the number of seals, large and small, counted on a certain piece of ground. But I found insurmountable obstacles. In the first place, the method required not only a very detailed and accurate topographical survey on a large scale, of each rookery, but the calculation of the area presented an exceedingly difficult problem. No two pieces of ground are alike. In some the beach is smooth and the seals are lying close; others are covered with smaller or larger rocks and stones, where the seals lie scattered as a matter of necessity. In other places, again, there are open spaces or thin spaces. Then, again, the outlying rocks and reefs defy close calculation as to number and area. On Copper Island small herds of seals would be found in corners and coves, on ledges of cliffs, and under overhanging rocks, sometimes entirely out of sight and most times beyond computation. I found that every factor of the calculation would have to be estimated averages, and that these averages in their turn had to be founded upon estimated items; in short, that the whole calculation would have to be a product of guesses multiplied by guesses. As we have to deal with large figures, it is evident that a mistake in the estimated factors must result in disastrously great mistakes in the total number.

Suppose, for instance, that I had "estimated" the area covered by the seals on both islands to be 4,000,000 square feet. If I "estimated" the average ground covered by a seal (mother, pup, and bachelor) on the rookeries to be 2 square feet, I would obtain a total of 2,000,000 seals on the Commander Islands. But, on the other hand, if I guessed that on the average a seal, large and small, on the rookery occupies 5 square feet—and this would possibly have been more nearly correct—I would get only a total of 800,000 seals, large and small. According to this method, various persons might estimate the number of seals on North Rookery, Bering Island, from 20,000 to 120,000, and yet it might be impossible to convince any of them that they were mistaken.

A numeration of the seals being utterly valueless unless accurate, or at least approximately accurate, I naturally regarded such an estimate of the number of seals on the rookeries not only as useless, but as downright pernicious. Actual counting being impracticable, and an individual judgment of the number being about as valueless as the above method of calculation, unless acquired by a very long practice, I gave up all attempts at presenting figures.

When, after twelve years, I again visited these rookeries the same question confronted me. In one place, where I had an unusually good opportunity, I tried to make an estimate of the average area occupied by a seal on that particular rookery. On July 16, watching the seals before me on Kishotchnoye Rookery, Bering Island, I wrote in my notebook as follows:

Here is a harem right in front of me, 1 sikatch, 16 matki, and about as many pups. They are lying as close together as about the average, and they easily cover a piece of ground 20 by 20 feet, 400 square feet, or more than 11 square feet per animal, pups and all. Ten square feet per animal for this rookery is, therefore, I think, a fair estimate.

But when I came back to the North Rookery and tried to apply my estimate, I was entirely at sea. I could not make up my mind whether the seals on the average were lying as close as above, or closer. Of course, I could see places where they were thicker, and others where they were thinner, but I could not, to my own satisfaction, strike an average, if for no other reason, because there were great portions of the rookery of which I could get no general view. Under those circumstances I would have regarded it as the merest humbug to present any figures pretending that they meant anything. Consequently, I wasted no further time upon getting at the probable number of seals on the Commander Islands rookeries.

The only method which promises reliable results is the one adopted now on the Pribylof Islands by the experts of the United States Fish Commission, viz, to actually count the number of seals on several large tracts of rookery, each of the size of an acre or more. In this way an average per acre may be obtained, which, multiplied by the computed acreage of all the rookeries, will give an approximate number which may not be too far out of the way. But, unfortunately, this method is hardly applicable to the Commander Islands, for various reasons, chief of which is the impossibility of making an actual count over a sufficiently large area to insure a reliable average. The rookeries are so very different among themselves that it would be necessary to have a separate count of each of them.

COMPARISON BETWEEN THE CONDITION OF THE ROOKERIES IN 1882-83 AND 1895.

BERING ISLAND.

NORTH ROOKERY, 1882-83. (Plate 7.)

When I first visited the northern rookery, thirteen years ago, there were three distinct breeding areas, viz, the Reef and Sivutchi Kamen, counted as one; a smaller patch between Babin and the creek, and Kishotchnaya. The bachelors hauled out on many of the outlying rocks surrounding the reef, and also in the rear of it on the smooth, white parade-ground. A large patch of them occupied the space back of the breeding-ground at Babin, large numbers extending a considerable distance back on the grassy area later in the season. Between the creek and Kishotchnaya there were three patches of bachelors. The whole distance from Sivutchi Kamen to Blizhni Mys, therefore, was practically one continuous seal-ground. The breeding-grounds at Kishotchnaya were surrounded by a heavy fringe of bachelors, who also sported in great numbers on the smooth, gravelly space in the rear of the rookery. South of Kishotchnaya, between the latter and Maroshnik, were again two separate patches of bachelors. In 1883 for the first time bachelors were known to haul out regularly throughout the season on the beach called Kisikof, beyond Maroshnik. They used to haul out there—and even as far south as Fontanka—late in the season, but their permanent settling on the beach in question was then regarded as an indisputable proof that the rookeries were increasing. It was at this last-mentioned point that the *Otome*, an English schooner, with a Japanese crew, made a raid during a dark night in August, 1883, and killed 300 to 400 seals. The mate was captured by the natives and the schooner the next morning by Mr. Grebnitski, on board the steamer *Aleksander II.*

The rookeries were in excellent condition, both as to quantity and quality. All classes of seals were well represented, and only skins of standard size were taken. This was particularly the case in 1883, when the company's representatives had very

strict orders not to accept a single skin under 8 pounds. During that year 50 per cent more skins could easily have been taken, but for business reasons the company wished to reduce the catch as much as possible, and it was only after some strong pressure was brought upon Captain Sandman by Mr. Grebnitski that he agreed to take as many as he did.

It is a fact well worth mentioning that even in those days females and pups got unavoidably mixed up in the drives. The percentage was not very great, but great enough to be a distinct feature of the drives on this island. However, as the drive progressed they were pretty successfully weeded out, and comparatively few reached the killing-grounds. Killable seals being plentiful, pods of females were allowed to escape along the route of the drive, even though they might include a few bachelors.

NORTH ROOKERY, 1895. (Plate 8.)

Upon inspecting the North Rookery again last summer I found a great change in many respects. Before reaching the rookery itself the absence of fresh or decaying carcasses on the killing-grounds was in marked contrast to the noisome sight and smell which used to form the first impression of the visitor arriving at the village. Nowadays every carcass is utilized. The choice parts of the meat are salted down in the many boxes and barrels dotting the ground in the rear of the killing-grounds, while the rest, including the entrails, are put in holes in the ground for winter food for the sledge-dogs.

On the rookery itself the first change which struck me was the fact that the entire beach between Babin and Kishotchnaya was depleted of seals—not a single breeding seal between Babin and the creek, nor a bachelor—all the way to Kishotchnaya. Later on I found that the hauling-grounds south of the latter place were also deserted. Instead of the imposing series of breeding and hauling-grounds from Sivutchi Kamen to Kisikof, I found only two patches of breeding-grounds, now forming almost two distinct rookeries—the Reef and Kishotchnaya.

I was prepared for a diminution of the seals, and it caused me, consequently, no surprise. On the other hand, I was considerably surprised at finding (July 8–10 and July 15–20) the *breeding-grounds* of the Reef outlined very much as I had seen them in 1883.[1] The bulk of the harems were located on the western side of the Reef, rounding the point of the "sands" and extending in a long, narrow horn south along the eastern edge of the latter. A narrow band obliquely across the "sands" formed a connection and separated off an oval bald spot of the white ground toward the northern extremity of the "sands." It is a noteworthy fact that this "bald spot" was an equally characteristic feature of the rookery in 1883 as in 1895. But what I did miss was another connecting band, viz, between the southeastern extremity of the breeding-seals toward the one alluded to above. While thus the distribution on the whole was the same as formerly, there was a perceptible shrinkage in the width of the areas covered by the seals, and it seems to me also in the density of the seals, though of this I can not be so sure. The rookery is looked at so much from the side that it is very difficult to judge correctly of the space between the seals.

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[1] When I first saw the rookery on July 4 it had not quite filled out yet, and I thought the depletion very great indeed; there was then no sign of the oblique belt across the sands, and the seals at the southeast corner formed a small, isolated herd.

To show the changes from 1882 to 1895, I submit some illustrations and two maps, which need some words of explanation.[1]

The drawing submitted (pl. 20) is taken from a photograph of a pencil sketch made by me July 30, 1882. Mr. Grebnitski, in going to St. Petersburg in the autumn of 1882, was anxious to have it accompany his report, and upon his arrival at San Francisco had a photographic copy made, which he sent me, and which is here reproduced. Like most drawings, the vertical dimensions are exaggerated, but on the whole it gives a fairly accurate representation of the rookery. The inner edge of the breeding-grounds are obscured by an immense number of bachelors on the "parade" or "sands," but the sketch shows pretty conclusively that the salient features are yet maintained. The photograph by Voloshinof (pl. 27*a*), taken in 1885, unfortunately is not very clear, but there is enough in it to show that the breeding area, so far as it can be seen from the direction of the salt-house, has shrunk comparatively little. My photographs (pl. 21) were taken from practically the same standpoint as the sketch and Voloshinof's photograph, and they afford as good a comparison as can be expected from photographs taken at such a distance. Those taken from a somewhat different standpoint, viz, from the driveway (pl. 22), give perhaps a better idea of the rookery, small as they are.

The map representing the seal-grounds in 1883 (pl. 7) was sketched on August 21, and shows the distribution of the seals on that date—hence the lack of definiteness to the areas of red and the extension of the bachelor seals into the grass-covered area. The map showing the location of the seals in 1895 (pl. 8), however, represents the seals as they were located July 17 and 19.

At *Kishotchnaya* I found the same state of affairs as on the Reef, only that the patch had shrunk still more and the seals apparently covered the ground less densely than on the Reef. This last observation, however, is not to be relied upon, as the breeding-ground can be looked down upon from a much greater elevation (70 feet), though at a greater distance. Bachelor seals in small numbers hauled out on the outer rocks and in among the females in the rear of the rookery, but the center of the "parade" ground was deserted all summer, and never a seal entered the posterior third of the latter, now covered with a scanty growth of tufted grass.

It was at once apparent that there was a low percentage of *bulls* on both rookeries, though at the Reef I afterwards found that the condition was not quite so bad as I first was led to believe. Upon my third visit to the rookery, when the wind was favorable for approaching it from the west side, I discovered that there were a good many more bulls proportionately to the females on that side than on the eastern half, which is the one first reached and most commonly seen. The formation of the ground made it utterly impossible to make a reliable estimate of the average number of females to each bull by counting a sufficient number of harems. At Kishotchnaya, however, the opportunities were more favorable, and on July 16 I averaged at the south end of

[1] Dr. Slunin in his recent report (Promysl. Bog. Kam. Sakh. Komand. Ostr.) has been singularly unfortunate in misunderstanding an old map by Mr. Grebnitski with regard to the extent of the rookeries on Bering Island. In the legend on plate 7 the dotted areas are represented as being the "rookeries according to Grebnitski." I have the original map, the so-called "Sandman-Grebnitski" map, before me, and can assert positively that Grebnitski never meant to represent the rookeries by the dotted areas, which are nothing else but the reefs surrounding the island. Of course Grebnitski did not intend to convey the idea that more than 60 miles, or half the entire coast line of Bering Island, were occupied by the rookeries.

that rookery about 50 females to a bull, while at the northern end the harems appeared smaller, most of those counted containing 15 to 25 females. A great many females were in the water that day, however; so in all probability the whole rookery averaged no less than 40 females to the bull. This proportion did not seem to be the result of or to have caused any lack of vigor in the males, for there was quite a number of large *half-bulls* skirting the rookery or hauled out on the outlying rocks, looking longingly toward the breeding-grounds.

The greater falling off in this rookery was due to the decrease in the number of *bachelors*. But instead of affecting all classes this diminution was chiefly confined to the younger ones. Last summer all the skins were weighed individually on a spring balance as the killing went on, and an accurate tally kept. I submit below a table of weights of the skins taken in 13 drives between July 14 and September 13, 1895. From this it will be seen that no single skin under 7 pounds was taken, and of this weight only 235 skins; that in 4 drives not a skin under 8 pounds occurred; that in none of the drives was the average weight less than 9.7 pounds; that of 6,725 skins, 5,558 weighed 9 pounds and over; and that the average weight of these 6,725 skins was 10.3 pounds. This table is also very interesting, showing how uniform was the size of the animals driven during the whole period of two months. Its true significance, however, can only be appreciated when it is remembered that the rookeries were scraped absolutely clean, and that not a seal was allowed to escape that would have yielded an acceptable skin. It can be stated with almost absolute certainty that there was not a bachelor seal on North Rookery, Bering Island, of the class yielding 6-pound skins.

Weight of skins taken in 13 drives on North Rookery, Bering Island, 1895.

Date.	7 lbs.	8 lbs.	9 lbs.	10 lbs.	11 lbs.	12 lbs.	13 lbs.	14 lbs.	15 lbs.	Total.	Average.
1895.										*No.*	*Pounds.*
July 14	5	90	74	61	48	53	11	4	2	348	9.8
19	4	70	90	237	75	60	8	1	0	545	10
29	0	53	110	138	211	161	50	10	0	733	10.7
Aug. 2	0	42	54	140	150	140	90	0	0	616	10.9
4	9	35	40	27	31	50	20	5	0	217	10.3
6	0	56	107	194	241	114	103	60	0	875	10.9
8	0	10	30	60	48	11	20	10	0	189	10.6
12	25	100	100	80	90	36	40	61	0	532	10.3
22	4	85	139	215	203	179	28	52	0	905	10.6
24	15	40	35	28	46	38	14	16	0	232	10.4
31	104	211	171	62	103	120	100	9	0	880	9.7
Sept. 10	50	93	80	66	85	40	35	10	0	459	9.8
13	19	47	34	20	29	16	17	12	0	194	9.8
Total	235	932	1,064	1,328	1,360	1,018	536	250	2	6,725	10.3

Though not literally absent, the *yearlings* were practically so. From the next table, which shows the number of each class of seals contained in the same 13 drives, it will be seen that out of 29,112 seals driven to the killing-grounds only 540 were yearlings, or 1.86 per cent. It was a constant source of wonder on Bering Island, in 1895, what had become of the yearlings. From time to time it was confidently predicted that they would turn up "later," but they did not come at all. There was a slight proportionate increase after the middle of August, but too trifling to amount to anything. And again I must emphasize the fact that the rookery was scraped clean in search of seals. This fact is startlingly disclosed by the following table, and because of its great importance it requires a full explanation.

Details of 13 drives on North Rookery, Bering Island, 1895, showing sex and age of seals driven.

Date.	Killed.	Escaping.				Total driven.	Remarks.
		Females.	Yearlings.	Pups.	Bulls.		
1895.							
July 14	348	1,305	0	13	11	1,677	
19	545	1,090	11	69	9	1,724	
29	733	1,738	23	35	13	2,542	
Aug. 2	616	1,436	14	67	8	2,141	
4	217	779	9	35	7	1,047	
6	875	2,014	5	159	11	3,064	
8	189	1,134	5	63	4	1,395	
12	532	2,077	74	104	5	2,792	
22	905	2,928	173	295	8	4,309	
24	232	1,265	56	51	4	1,608	
31	880	2,259	55	108	5	3,307	
Sept. 10	459	1,718	38	69	8	2,292	14 stagy.
13	194	825	77	115	3	1,214	51 stagy.
Total	6,725	20,568	540	1,183	96	29,112	
Percentage of total driven	23.10	70.65	1.86	4.06	0.33	100.00	

Upon my arrival, in 1895, I impressed upon Mr. Grebnitski the desirability of having such a census prepared, and suggested that Selivanof, the kossak in charge of the rookery, be ordered to undertake the work. Mr. Grebnitski, fully aware of the great importance of knowing exactly what classes were represented in each drive, at once took up the suggestion and ordered Selivanof to make a detailed tally of each drive according to the scheme I furnished. The drive on July 19 I counted myself conjointly with Selivanof, and the tally sheet is here produced to show how the work was done and how much reliability can be placed upon it. The seals killed and those escaping from each pod, as it was culled and slaughtered, were separately counted, Feoktist Ivanof Korsakovski counting the dead ones, Selivanof and I those allowed to escape.

Tally of drive taken July 19, 1895, North Rookery, Bering Island.

Pod No.	Killed.	Escaping.				Pod No.	Killed.	Escaping.			
		Females.	Yearlings.	Pups.	Bulls.			Females.	Yearlings.	Pups.	Bulls.
1	8	15	2			22	20	21	1	4	
2	9	35				23	10	30	1	1	
3	7	38		1		24	26	10	1	2	
4	13	28				25	11	21			
5	16	34	1	2		26	12	19			1
6	11	32				27	18	23		2	2
7	18	22				28	23	16		9	
8	11	28	1			29	28	43		6	
9	7	23		2		30	12	35		3	
10	9	25	1			31	22	42		1	
11	12	9	1	4		32	20	51		9	
12	11	26				33	11	12			
13	6	20				34	7	21		1	
14	9	26		1		35	15	40		6	1
15	21	28		4		36	12	25		2	
16	3	34				37	10	23		2	
17	16	31		1	1	38	11	35		2	
18	9	28				39	30	51		1	2
19	13	35			2						
20	20	27	2	3		Total	538	1,090	11	69	9
21	11	28									

The accuracy of the above tally is attested by the fact that the number of skins taken in this drive was 545. Sometimes the killed ones of the previous pod were lying so close to those being counted that it was difficult to ascertain the exact number, in which case the smaller figure was noted. And so with the escaping ones. Selivanof and I counted separately; if we differed, and a recount was not practicable, we took

the lowest figure. The percentages are, therefore, very nearly correct. If there is any error, it is in understating the number of females, but I am sure that the possible error does not exceed 1 per cent.

The figures of the 13 drives in the table previously given were ascertained in the same manner, and I have no doubt that they are essentially correct. No tally was kept previous to the drive on July 14, and I failed to obtain the details of the drive on July 24, but there is no reason to believe that the percentage of the classes was different in these drives, except that I was informed that there were no females or pups in the first drive, June 13. In order to complete the record of this rookery for 1895, I submit the following table of the skins taken in each drive during the summer season:

Total number of skins taken on North Rookery, Bering Island, during the summer season of 1895.

Date of drive.	Skins.	Date of drive.	Skins.
June 13	110	Aug. 6	875
June 25	187	Aug. 8	189
July 6	262	Aug. 12	532
July 14	348	Aug. 22	905
July 19	545	Aug. 24	232
July 24	1,057	Aug. 31	880
July 29	733	Sept. 10	459
Aug. 2	616	Sept. 13	194
Aug. 4	217	Total	8,341

Looking again at the table of the classes in the 13 drives, we note that it was necessary to drive off over 29,000 seals in order to obtain 6,725 skins, and that of those 29,000 no less than 20,568 were females. As already stated, there is no reason to suppose that the percentage of females differed materially in the other 4 drives, except one. If, therefore, we calculate the corresponding figures for a total of 8,231 (8,341−110) skins, we find that in order to obtain 8,341 skins, the total catch for the season, it was necessary to drive off to the killing-grounds 35,741 seals, of all ages, of which *the astounding number of 25,174 were females.* In this count are not included such females as were allowed to escape along the road of the drive, although the number of females thus culled was comparatively few, as the men were afraid of letting a single killable bachelor escape.

Nothing could better illustrate the straits to which this rookery has come. On the other hand, nothing could better demonstrate how little the driving disturbs the seals. Here is a rookery where the females have been driven probably as long as seals have been taken, though not in the same proportion as now. Yet, the females return to be driven over and over again, and the *breeding-ground* is the part of the rookery least affected in the general decrease.

A great amount of mortality due to starvation was observed among the pups, but is here only alluded to, as I have treated of that question in another connection (p. 78).

SOUTH ROOKERY, 1882. (Plate 9.)

This rookery, although probably the remnant of the innumerable multitudes which Steller speaks of, has not been of much account of recent years. After the interregnum, 1869–1871, it was so insignificant that no regular catch seems to have been made until 1880, although occasionally, i. e., before and after the season closed on North Rookery, a few seals were killed at Poludionnoye in order to get fresh meat for the main village, Nikolski. Thus, in 1878, 50 were killed in June and 30 on November 5.

The result was that the rookery was gradually increasing. Finally, in 1880, it was deemed sufficiently large to station a small force of men under Mr. Volokitin at the place, and in that year 787 skins were taken. It seems, however, that the capacity of the rookery was underestimated and not enough salt was landed, so that no more could be taken care of. In 1881, in spite of the complaint that although there are "many sikatchi on both rookeries" there are "but few holustiaki, mostly in the water," the South Rookery yielded 1,150 skins. The following year (1882) the catch was 1,410.

When I visited this rookery on August 21, 1882, I found the entire beach between the first and second cape west of the waterfall covered with seals, the breeding seals occupying the portion nearest to the water, the bachelors patches at both ends and in the rear up to the inner grass-covered belt.

SOUTH ROOKERY, 1895. (Plate 10.)

How different when I approached the same ground again August 17, 1895, thirteen years later almost to the date! Only a handful of female seals were left at the extreme western end of the rookery.

I am very fortunate in being able to present copies of two photographs taken by the late Colonel Voloshinof in 1885, which, as they are taken from almost the same standpoint as one of my own (pl. 29), afford excellent comparison between the conditions of Poludionnoye Rookery then and now. In the right-side half of his double picture (pl. 31*a*) a series of smaller rocks in the water extends from the beach to the outer end of the west reef. This series of rocks will be recognized toward the lower left-hand corner in my photograph (pl. 29), and will serve to orient the reader. It will then be seen that the entire beach, which, in my picture of 1895 is absolutely bare of seals, is covered with thousands in Voloshinof's picture of 1885, and that the compact body of seals then extended even a good distance beyond. To complete the comparison I add another photograph of mine (pl. 28) looking in the opposite direction (toward the waterfall), which shows the utter desolation of the entire beach beyond the little black patch.

As for the proportions of the various classes of seals on this rookery I found the conditions to be similar to those on the North Rookery. It was reported in Nikolski that there had been only 1 bull on the rookery in 1895, but upon inquiry at the rookery I was informed by Nikanor Grigorief, the native in charge, that the actual number of sikatchi had been 5. This number may be considered exact, and the number of females to each bull was, therefore, probably nearly 100. There were plenty of pups when I visited the rookery, and no barrenness of the females was suggested.

By dint of hard scraping no less than 564 skins were secured in 1895, 159 of them, however, between August 17 and September 9.

COPPER ISLAND.

KARABELNOYE ROOKERY, 1882–83. (Plate 11.)

The distribution of seals on this rookery, as I found it during the week July 3–10, 1883, is shown on the map (pl. 11). Every available space under the cliffs was occupied by breeding females. Even the ledges at the foot of them and the lower portion of the steep ravines were full of them. The bachelors were obliged to be satisfied with the outlying reefs and rocks, with the beach on the east side of Karabelni Stolp, and the rocky beaches at Vodopad and beyond. The rookery was in excellent condi-

tion, all classes of seals being well represented. In fact, there was unquestionable proof that the rookery was increasing.

Curiously enough this fact was brought home to the natives located at Karabelni by the circumstance that they were unable to obtain in good season the number of skins required from this rookery. When I arrived at Karabelni in the beginning of July the natives were deeply concerned because of their failure to obtain the last 1,000 skins. As the families are paid for each skin brought to the salt-house, this meant a serious loss to those stationed at this point. They finally decided to go to Glinka, where the season was already over, and there got all the skins they wanted. In answer to my inquiry as to the cause of their failure to obtain the skins at Karabelni I was told that it was because the rookery was increasing. Self-contradictory as this statement appeared, it was nevertheless easily explained. The main hauling-ground of the bachelors, i. e., the one yielding most skins and from which the seals could be driven, was the Karabelni Stolp. Looking at the map (pl. 11) it will be seen that at the base of the neck there was a large breeding-ground. The breeding seals were increasing here to such an extent as to occupy the whole space along the beach and actually shutting off the hauling-ground, thus making it impossible to drive any seals from that place. The men were therefore obliged to take the skins at Vodopad and Krepkaya Pad, which meant that they had to carry every skin on their backs across the island. When it is considered that the population, even under ordinary circumstances, was rather insufficient for the work, it may easily be understood what a hardship this increase of the rookery involved. But not only the breeding seals were increasing, the bachelors were also extending their territory. The result was that skins were taken in Malinka Bukhta for the first time. At this place the women did the skinning and carrying, for even here the skins had to be carried, while the men were engaged at Krepkaya Pad.

In addition to the map I have submitted three original field sketches of the rookery as I found it on July 3, 1883 (pls. 41–43). While making no claim for artistic merit I do claim for them sufficient accuracy for an intelligent comparison with my photographs of 1895, which were taken from the identical standpoints. The sketches have not been touched since I left the rookery in 1883 and are here reproduced in facsimile so as to eliminate the possibility of even unintentional alterations.

KARABELNOYE ROOKERY, 1895. (Plate 12).

On July 31, 1895, Mr. Grebnitski and I landed in Stolbovaya Bukhta and pitched our tent on the beach just west of the killing-ground. It was very foggy and the water high, so that we could not pass the point into Martishina Bukhta. Next morning, at 4.30 a. m., the fog still prevailed, but the water was low and we made our way along the beach to the rookery. We passed on to the Stolp without meeting a seal, where in 1883 thousands of breeding seals blocked the way of the drives. Only a small solid patch, leaning on the south base of the cliff, remained, an isolated outpost at this end of the rookery. At the Stolp itself we found a couple of small harems only at the northern end, and towards the southern extremity a small patch of bachelors, hardly more than a dozen. In the distance I could discern through the fog faint outlines only of the breeding-grounds.

After breakfast the fog lifted and I ascended the bluffs, which rise 300 feet above the breeding-grounds. The photographs which are herewith appended (pls. 38–40) were taken from the various stations at the edge of these bluffs, marked on the maps, care being taken to select the same points from which I had made my sketches twelve years previously.

I found that while on the whole the breeding grounds had retained their former shape—necessarily, because of the natural conditions of the beach—there was a great thinning out of the ranks of the *females*. At the same time a large area at the northwestern end had become nearly depopulated. At first I credited the thinness of the breeding herds to the bright weather, but another visit to the heights the next morning showed no improvement.

That day I saw no *bachelors*, except the little patch at the Stolp; none at Vodopad and Krepkaya Pad. At Malinka Bukhta, I was informed, they had ceased to haul up several years ago. The next day we saw a few more bachelors—a somewhat larger patch—at the Stolp, and two other patches, of possibly a hundred seals each, one on each side of the Vodopadski Nepropusk.

But one feature that struck me with surprise was the great number of *bulls* and *half-bulls*. This abundance of old males was particularly interesting, coming, as I did, directly from Bering Island, where this element was so scarce.

Pups were present in good proportion.

The decrease in the yield of this rookery has been considerable. While as far back as 1881 6,500 skins were secured without trouble, it was impossible for the men, in 1895, try as hard as they might, to secure more than 2,000. They were given full swing and encouraged to take as many as possible, though they needed no special encouragement, for the decrease in skins meant a corresponding decrease in food and comfort during the following winter. Moreover, the season was extended to the first week of September, and yet with no better results. Between August 12 and September 10 they could scrape together only 188 skins.

GLINKA ROOKERIES, 1882–83. (Plate 13).

The capacity of Glinka used to be more than double that of Karabelni, having in good years yielded over 20,000 skins. The best hauling-grounds were Palata, Zapadni, and Pestshanaya, but bachelors then hauled out as far as Babinskaya Bukhta in the south and Gorelaya Bukhta in the north. These distant grounds were only drawn upon occasionally, and the grounds between Urili Kamen and Palata Mys furnished the bulk of the skins. Of these Pestshani hauling-ground was the most prolific and the handiest, although the driving was very severe before the new salt-house was built, and single drives yielding more than 4,000 skins from this place were no exceptions.[1]

The principal breeding-grounds occupied the inaccessible beach between the Stolbi in Gavarushkaya Bukhta to Palata Mys, comprising Sikatchinskaya and Zapalata, the gully and basin north of Palata, and, finally, the family grounds designated as Zapadni or Zapadni Mys. Palata, to the looker-on coming over the mountains, was probably the most impressive rookery view in the whole Commander Islands group. The solid blackening masses of breeding seals, filling the gully to overflowing and extending under the bluffs and along the beach on both sides, was a sight never to be forgotten. My original sketch, made in 1883 from a prominent point 800 feet above, is unfortunately lost or mislaid, and I am therefore obliged to substitute an elaboration of it (pl. 52) made shortly after my return, probably in January or February, 1884. I know it to be a pretty faithful rendering of the sketch, but of course the latter would have been more authentic.

Zapalata and Sikatchinskaya were the mainstay of the rookery, however. There the breeding seals were absolutely safe against all possible interruptions from the land

[1] Dr. Slunin reports that in 1887 a drive yielding 6,000 took place from this hauling-ground.

side, while the bays themselves are wonderfully sheltered by reefs and outlying rocks, thus affording admirable places of safety for the growing pups, features which will be fully appreciated by an inspection of plates 55 and 56.

To illustrate the condition of these rookeries during the palmy days of the business I am fortunate enough to be able to copy a couple of Voloshinof's photographs (pls. 53 and 57*a*) made in 1885, to which I shall refer more in detail later on.

GLINKA ROOKERIES, 1895. (Plate 14.)

On the 2d of August I approached the Glinka rookeries in a boat from the north and proceeded along their entire front from Lebiazhi Mys to Babinskaya Bukhta, where we camped. I saw breeding seals in most of the places where I formerly saw them, but in vastly reduced numbers. *Bachelors* were also seen, but they were few and far between. At Pestshani hauling-ground, the place which once supplied many thousands, and which even as late as 1893 furnished 3,137 skins, there was not a single bachelor. True, a drive had been made from that place only a few days earlier, which had resulted in 700 skins, but these 700 skins were all that this famous hauling-ground yielded in 1895.

However, the location of nearly all the former hauling-grounds was marked, not so much by little bunches of a dozen bachelors or so, but, curiously enough, by a line of black *half-bulls*. They had hauled up and occupied the beaches with regular intervals, much as do the old bulls in spring before the arrival of the females; in fact they were in a measure playing sikatch! These lonesome, patiently waiting polusikatchi were first seen at the old hauling-grounds on both sides of Lebiazhi Mys, and then on the west side of Peresheyek and of Pestshani Mys, and finally at the eastern end of Babinskaya Bukhta. At these places they had hauled out by themselves. But, in addition, hundreds of these nearly mature young bulls (or probably mature, though not strong enough to fight the older ones) skirted the breeding-grounds, hauling out on outlying rocks and paying attention to the females coming out for a swim or a trip to the distant feeding-grounds. On the breeding-grounds dark-haired, vigorous-looking bulls abounded.

This superabundance of vigorous, mature males was a strongly marked feature of the rookery. This is the more remarkable, if we remember that it was already late in the season when I visited Glinka and that, although I stayed until August 11, I saw no diminution of it. The natives also informed me that on account of the still greater number of bulls earlier in the season the fighting had been violent and incessant on the rookeries. This abundance of bulls I have been told has been noticed for several years.

In strong contrast to this exuberance of virility was the thinness of the *female* ranks. They spread over nearly the same territory as formerly, but the lines had shrunk and in many places there were large bare gaps. The magnificent Palata showed many of the characteristic features that I knew so well, and yet it was only the shadow of the old rookery. The line running backward up the gully was there,—but it was very thin and narrow and broken in places. A comparison of my old sketch (pl. 52), taken at high water, with my recent photograph from the identical standpoint, low water (pl. 51), will give some idea of the difference I saw. Although taken from a point somewhat different from mine, Colonel Voloshinof's photograph of Palata as it looked in 1885 (pl. 53*a*) fully bears out my sketch, when it is remembered that

he was standing several hundred feet lower to the right and that consequently the solid belt of seals at the base of Palata must look so much narrower on his picture than on mine. My other photographs (pls. 48, 49), looking toward Palata and Sabatcha Dira from the outlying rocks off the former, serve to more fully illustrate the disconnected and thin character of the breeding-grounds in 1895.

And as with Palata, so with Zapalata. The change was less striking, though by no means less radical. On the contrary, Zapalata, in proportion, was even more deserted. It is a source of great satisfaction to me that in photographing this rookery I happened to place my camera on the exact spot where Colonel Voloshinof ten years previously had exposed a plate, and although it evidently met with some mishap, so that this picture is one of the less satisfactory ones, I have reproduced the two (pls. 56 and 57*a*). On the whole light beach my photograph shows nothing but stones, while the same area in Voloshinof's is teeming with thousands of breeding seals. By turning my camera in the opposite direction I obtained the other picture (pl. 55) showing the same depleted condition.

To complete the series of photographs illustrating the condition of the various parts of the rookery, I finally reproduce one by Mr. Grebnitski, taken from the rocks in Sikatchinskaya Bukhta August 3, as I had no opportunity to photograph it myself. It tells the same story (57*b*).

The total number of skins shipped from Glinka in 1895 was 4,809 (including a few hundreds of the autumn catch of 1894), a trifle more than one-half the catch of the previous year.

In view of the great number of half-bulls and bulls it is interesting to note that the skins both from Karabelni and from Glinka were unusually small. No regular tally of the weight of the entire catch was kept on Copper Island, but upon our arrival there was a great complaint of the lightness of the skins. During my stay at Glinka, from August 2 to 11, the natives were unable to take more than one small drive, in spite of their anxiety to make more money and to obtain more fresh meat. The skins of this drive were weighed according to Mr. Grebnitski's directions, who himself kept tally. The weight of the skins was noted to the half pound, but to simplify the list and make it easily comparable with the corresponding ones upon Bering Island I only recorded whole pounds; a skin weighing $7\frac{1}{2}$ pounds, for instance, I counted as 8 pounds, while $7\frac{1}{4}$ pounds was recorded as 7. Mr. Grebnitski's tally and my tally will differ to that extent, but the average will undoubtedly be very nearly the same. This average, it will be seen, is scarcely $7\frac{2}{3}$ pounds. When I visited Copper Island in 1883 the company refused every skin under 8 pounds.

Weight of skins brought to the salt-house at Glinka, Copper Island, August 8, 1895.

Weight.	Number.
Under $6\frac{1}{4}$ pounds ($4\frac{1}{2}$ to $6\frac{1}{4}$)	35
7 pounds	108
8 pounds	40
9 pounds	17
10 pounds	11
11 pounds	6
12 pounds	5
13 pounds	2
14 pounds	3
15 pounds	1
Total number of skins	228
Average weight of skins .... pounds	7.6

COMPARATIVE CONDITION OF THE BERING ISLAND AND COPPER ISLAND ROOKERIES, 1895.

In what little there has been said and written about the seal industry on the Commander Islands it has always been assumed that the conditions, aside from the difference in the physical aspect of the rookeries, were the same on both islands constituting the group. And this was actually the case not very long ago, at least in 1882–83, and, so far as I could ascertain, up to 1890. In that year, it is said, the bachelors were becoming somewhat scarce on Copper Island and some active work had to be done in order to secure the desired quantity, but inasmuch as this quantity appears to have been the largest ever shipped from Copper Island, the falling off can not have been excessive, though it may have been apparent on the hauling-grounds.

In 1892, however, the decrease in the number of females on Copper Island became serious enough to cause public comment, while on Bering Island difficulty was experienced in obtaining the requisite, though now limited, number of bachelors.

Whatever the cause of the recent disturbance of the equilibrium of the rookeries on the Commander Islands, each island has been affected differently, and the conditions to-day of the rookeries on Copper Island deviate radically from those of Bering Island. It may be useful to compare them point for point.

In Bering Island the number of females in proportion to the mature males is very much greater than on Copper Island. This results in an apparent deficiency in bulls on Bering Island and a corresponding superabundance of them on Copper Island.

In Bering Island the killable males are of great size, as proven by the weight of the skins, which in 1895 averaged over 10 pounds. The greatest deficiency was consequently in the younger seals, while yearlings were almost entirely absent. The proportion between the ages of the killables was quite reversed on Copper Island, where a lack of the older bachelors was seriously felt, while the great bulk of the skins taken were from the younger classes, the skins averaging probably less than 8 pounds.

As for the pups, it may be stated that they were abundant in proportion to the females on both islands, and no difference could be discovered in that respect. On Bering Island I found a considerable mortality due to starvation among the pups. On Copper Island no such thing was observed, but this negative result must not be taken as a proof or even an indication that no such mortality took place. It must be remembered that most of the breeding-grounds on Copper Island are inaccessible, and that it is almost an impossibility to distinguish the dead bodies of the pups from such a distance as it is necessary to watch them on Copper Island.

It was by the merest accident that I myself discovered the sad state of affairs on Bering Island, for if I had not gone over the rookery after the wholesale raid of the breeding-ground I should have remained in ignorance of the fact. The natives themselves were either concealing it, out of fear that they would be blamed, or, more likely, they were ignorant of the extent of the calamity. After the season is over the natives keep aloof from the rookeries, as they are strictly enjoined from disturbing the breeding-grounds without necessity. The simple fact, therefore, that I can report no unusual mortality on the Glinka or Karabelni rookeries proves nothing one way or the other.

RAIDING OF COMMANDER ISLANDS ROOKERIES.

The rookeries of Bering and Copper islands have always been a sore temptation to marauding schooners, especially those of the latter island, where, in addition to the fur-seals, there was a fair chance of obtaining a number of the costly sea-otters, a few of which would go a long way to pay for the expenses and risks of such an expedition. The material is not at hand for an exhaustive list of all the attempted and accomplished raids on the Commander Islands rookeries, but I shall give a sufficiently detailed account to show that considerable damage has been done by the pirates.

Leaving out of consideration the possible raids during the flourishing times of the whale fishery in the forties, and coming down to recent days, we find that at first the raiders were attracted to Copper Island by their knowledge of the plentiful occurrence of the sea-otter on that island, a knowledge gained by many of them during their visits to the islands during the "interregnum." We thus find the American schooner *Three Sisters*, Captain Herendeen, caught on July 22, 1879, at anchor off the Northwest Cape of Copper Island, the mate and sailors camping ashore near the sea-otter rookery. Twenty-nine skins of grown sea-otters and 16 sea-otter pups were taken from her, but also 123 fur-seals, which it was claimed, however, were taken at sea. Instead of seizing the vessel, the authorities let her go with a warning. The seal skins found on her proved that sea-otter was not the only game looked for, and in the same year, on August 10, an unknown schooner, off Glinka, attempted to land three boats, but the natives frightened them off.

The year 1880 saw an increased activity on the part of the poachers, who were much emboldened by their successes in the Okhotsk Sea and the Kuril Islands. As early as July 7 the *Three Sisters*, of San Francisco, Captain Beckwith, was seen at anchor off Glinka Rookeries, killing seals; the crew was driven off by the natives shooting at them. Mr. E. P. Miner (Brit. Counter Case, App., p. 113; Fur-Seal Arb., VIII, p. 700) gives the following graphic account of this raid:

> She was chartered by H. Liebes & Co., and was supposed to be going out on a sea-otter and fur-seal hunting expedition, but as a matter of fact all of us who shipped as hunters knew that the vessel had been fitted out for a raid on the rookeries on the Commander Islands. Early in July we started from the Alaskan coast for the Commander Islands, and about the middle of the month landed on the west side of Copper Island. We landed in the day time in a fog. There were three boats. We had killed about 800 seals before we were seen, but had taken none of them on board the vessel. A baidarka with natives in it came along then, and we knew that warning would be given to the people on the island, and we began skinning the seals. In about an hour what appeared to be fifty men came across the island to where we were, and began firing at us with blank cartridges. We started off at once, but when some distance from land began killing seals in the kelp. Then they fired on us with bullets, and we went on the schooner. All the skins we got of the seals we killed was 153. Before we made the raid on the seal rookery we had anchored at the north end of Copper Island, where sea-otters are plentiful, and while there a baidarka full of natives came out to us and served a warning on the captain, telling him that he must not hunt within 5 miles of the islands—the miles were, I suppose, meant for Russian miles. We went from Copper Island to the Kurile Islands to look for sea-otter, and after getting one sailed on the 4th August for San Francisco.

On July 13, 1880, a schooner was reported at anchor close to the beach of North Rookery, Bering Island, and being discovered had probably but poor success. Not so, however, with the schooner that raided the Glinka rookeries about two weeks later, killing "a number of seals, say about 400." This can hardly have been the *Otsego*, Captain Isaackson, flying the Dutch flag, which was boarded on August 6 by the steamer

Aleksander II at Glinka, but was found to have "4 to 5 fur-seals only." On the next day Mr. Grebnitski boarded the schooner *Alexander*, Captain Littlejohn. The latter swore that he had shot the 53 seals found on board, denying that he had been near a rookery, and was warned off. Captain Sandman on August 12 confiscated 4 sea-otters from the schooner *Flying Mist*, Captain Bradford, which was found at anchor "around the Northwest Cape (Copper Island) close inshore about 8′ SE. from rocks," but with "apparently no seals."

On September 1 the kossak and a watchman boarded the schooner *Seventy Six*, Captain Potts, off the Southeast Cape, Copper Island, finding only one man on board, the rest being on shore. The watchmen went after them, but the schooner's crew made directly for the vessel as soon as they saw them coming, and got away. "On shore the watchman found about 40 seal carcasses which the schooner's people had killed and skinned, all bulls."

The raiders did not confine themselves to Copper Island by any means, for on September 10 an unknown schooner visited the South Rookery on Bering Island, killing about 25 seals, and two days later a schooner, possibly the same, was reported "on the north side shooting seals at sea," but left on the approach of the steamer *Aleksander II*. After the departure of the latter, the schooner came in again on September 13, but the whaleboat which was sent ashore was driven away, by the natives firing at the crew, before any seals were killed.

Captain Littlejohn, in the schooner *Alexander*, evidently took no heed of the warning given him, for on October 16 he was on the Glinka Rookeries and took "some seals again," an exploit which he repeated on the moonlight night of the 18th, when he secured "a number of seals (mostly cows) before morning."

Although the record for 1881 is not quite so black, it is in some respects fully as interesting.

On Bering Island two schooners appeared at the North Rookery on October 8 and landed 6 whaleboats, killing many seals, mostly females and young ones. Mr. Grebnitski himself went to the rookery, but the schooner had already left. Exactly a week later two schooners again arrived off the North Rookery, possibly the same, landing 5 whaleboats early in the morning of October 16. This time, however, the natives were prepared, and 40 of them, well armed with rifles, met the raiders. The latter now opened negotiations, the captain offering a gold watch to the chief, money to the men, and whisky to all for the privilege of taking 300 fur-seals. The natives refused, and the raiders, after having examined some of the Berdan breech-loading rifles and having received an affirmative answer to their question whether the natives would shoot if they should attempt to kill any seals, withdrew. "Seeing that they could do nothing, they put to sea."

It is probably to a raid in 1881 that Mr. S. L. Beckwith's testimony relates (Fur Seal Arb., VIII, p. 810), in which he states that as "a mate on the vessel *Alexander*, belonging to Hermann Liebes, of which Captain Carlson was master," "in 1880, or thereabouts," he "went ashore and raided Copper Island, and got about 100 seals, and we would have got a great many more, for we had about 1,200 killed when we were fired upon. A Japanese vessel was there the day before raiding and several of the raiders were shot." This last information seems to tally with the following record from Bering Island: "October 11. A schooner has been at Staraya Gavan. Buried one Japanese."

The fact was that the natives, incensed by the numerous raids, were using their guns freely during 1881. Thus, earlier in the season the *Annie Cashman*, of San Francisco, went to Copper Island, and Mr. E. P. Miner states (Fur Seal Arb., VIII, p. 701):

> We landed there one clear day, and in $1\frac{1}{2}$ hours took 250 seals, and had them all on board before the natives came to where we were. We went away then, but came back the next night. We were fired on by the natives, and did not land.

It went particularly hard with the British schooner *Diana*, sailing from Yokohama earlier in the season. She had been raiding various rookeries on the Kuril Islands and finally went to Copper Island, where she came to grief. She anchored off Zapalata and a boat was immediately sent ashore. They did not reach it, however, for behind the rocks a large band of natives, under command of the kossak, Selivanof, were lying in wait. When the boat was well within range, the kossak gave the signal and a complete rain of bullets struck the unfortunate boat. One man was killed, one severely wounded, and the boat, nearly sinking, made the schooner with the greatest difficulty. It is said that fully 300 shots were fired by the natives. The *Diana*, now severely crippled, sought safety in flight, but on the way to Petropaulski unfortunately fell in with a Russian man-of-war—the *Strelok*, if I remember rightly. The suspicion of the commander was aroused, an investigation made, which resulted in the imprisonment of the crew and the confiscation of the vessel, in spite of the plea of the captain that no raid was intended and that the boat was sent ashore only to take water, of which the schooner was short.

The case was made the subject of diplomatic correspondence between Great Britain and Russia, and the latter power sent a revisor to Copper Island in 1882 to investigate the matter. His report was favorable to the natives, no doubt, for the Russian Government, in recognition of their meritorious conduct, invested the native chief of Copper Island with a silver-laced kaftan, while Selivanof was promoted to be a sergeant and a beautiful Toledo blade was presented to him upon which was engraved a suitable inscription commemorative of the occasion.

It was plain that something would have to be done to check this growing evil, which had already been assuming alarming proportions, but the authorities were puzzled how to proceed effectively. One or two large war vessels were already patrolling the region, but their service was very ineffective, as they did not take the risk of going close under the foggy and dangerous coasts of the islands. It was thought, however, that strict regulations for the whole traffic of trading and hunting in Russian waters, which would leave the schooners no excuses or technical loop-holes, would deter the marauders, especially in view of the past experience, and seeing that the Russian Government was in earnest in backing up the natives in their defense of the rookeries. A proclamation was therefore prepared and issued, first by the Russian consul at Yokohama and afterwards also by the Russian consul in San Francisco, the publication being specifically authorized by the Imperial Russian Ministry of Foreign Affairs. The consular warning was as follows:

NOTICE.

At the request of the local authorities of Bering and other islands, the undersigned hereby notifies that the Russian Imperial Government publishes, for general knowledge, the following:

1. Without a special permit or license from the Governor-General of Eastern Siberia, foreign vessels are not allowed to carry on trading, hunting, fishing, etc., on the Russian coast or islands in the Okhotsk and Bering Seas or on the northeastern coast of Asia, or within their sea boundary line.
2. For such permits or licenses foreign vessels should apply to Vladivostok, exclusively.

3. In the port of Petropaulovsk, though being the only port of entry in Kamtchatka, such permits or licenses shall not be issued.

4. No permits or licenses whatever shall be issued for hunting, fishing, or trading at or on the Commodore or Robben Islands.

5. Foreign vessels found trading, fishing, hunting, etc., in Russian waters without a license or permit from the Governor-General, and also those possessing a license or permit who may infringe the existing by-laws on hunting, shall be confiscated, both vessels and cargoes, for the benefit of the Government. This enactment shall be enforced henceforth, commencing with A. D. 1882.

6. The enforcement of the above will be intrusted to Russian men-of-war, and also to Russian merchant vessels, which for that purpose will carry military detachments and be provided with proper instructions.

(Signed) A. PELIKAN,
His Imperial Russian Majesty's Consul.

YOKOHAMA, *November 15, 1881.*

This proclamation was distributed to all outgoing vessels, and evidently had some effect, as the raids during the years following fell off very considerably. A few skippers, more desperate than the others, however, were still taking chances. Thus, on August 12, 1882, the schooner *Otome*, of Yokohama, with a Japanese crew, but European officers, raided the North Rookery on Bering Island, though with disastrous results. After having tried the watchfulness of the natives during dark and foggy nights for more than two weeks, three boats were sent ashore from the *Otome* on the 12th of August after dark. At Kisikof, the southern extremity of the rookery, about 350 bachelor seals were clubbed, and the skinning was already far advanced when the natives crept up to the pirates and captured the mate; the next morning the schooner was seized by Mr. Grebnitski on board the steamer *Aleksander II.* The *Otome* was finally taken to Vladivostok and condemned. The captain was charged with piracy, but Mr. Snow, who had passage in the schooner, was allowed to go, as there was no proof of his connection with the affair as owner or supercargo.

The fact that the proclamation did not entirely stop the raiding, induced the Russian authorities in 1884 to station a detachment of soldiers on the islands for their protection, as related elsewhere in this report, and the schooner *Sakhalien*, raiding the South Rookery on Bering Island, fell the first victim to the regulars.

The captains of the schooners were becoming wary, and, to avoid being captured within the 3-mile limit of the territorial waters, adopted the tactics of keeping some distance at sea, only sending their boats or canoes to kill the seals on or off the rookeries, as the case might be.

The first schooner caught in this practice seems to have been the British vessel *Araunah*, Captain Siewerd, which was seized off Copper Island on July 1, 1888, by Grebnitski, in the *Aleksander II.* The significant point was that while the schooner itself was not nearer than 6 miles, two of its canoes were hunting seals within half a mile of the shore, and, in spite of the diplomatic remonstrances by Great Britain, Mr. Grebnitski was fully sustained by Mr. Giers, the Russian minister for foreign affairs, in his letter of August 16, 1889. However, although caught as a raider, the *Araunah* was in reality a regular pelagic sealer from British Columbia, with Indian hunters and Indian canoes.

PELAGIC SEALING AT COMMANDER ISLANDS.

The tactics described in the closing paragraphs of the chapter relating to the raiding of the rookeries, of sending the canoes in among the breeding seals off the rookeries, to kill them in the water while the schooner remained at sea, were the forerunner of pelagic sealing around the Commander Islands. It was claimed by the crew of the *C. G. White*, Captain Hagman, who gave themselves up (in 1890) to the authorities on Copper Island, that they were blown ashore after having lost their vessel; but the natives evidently thought differently, for they fired upon three of the boats as they attempted to land, killing one man and wounding two, while seven bullets went through the boats. However, as the schooner was not captured, the men were sent back to San Francisco in the company's steamer. While it is true that the *James Hamilton Lewis* (formerly the *Ada*) was caught right under the South Rookery of Bering Island in 1891, by the Russian war vessel *Aleut*, it is certain that many of the 416 skins (90 per cent of which it has been stated were females) confiscated were killed at sea.

When but few seals were left on Robben Island and the Kurils to raid, the schooners fitting out in Japan turned their attention to following up the Commander Islands herd on its northward migrations along the outer side of the Kuril chain, adopting the regular methods of pelagic sealing. Owing to the necessity of having heavier and stronger vessels on that coast, because of the much more severe weather and the consequent greater risk, the pelagic sealing developed much slower on the Asiatic side than on the American, and played a comparatively unimportant rôle up to 1892.[1]

The latter year saw the total prohibition of sealing in the eastern, or American, part of Bering Sea, according to the *modus vivendi* between Great Britain and the United States pending the fur-seal arbitration by the Paris tribunal. The sealing fleet was already on their way when they were informed of the closing of Bering Sea, the result being that quite a number of the vessels, rather than return home, made straight for the Commander Islands to try their luck there. No less than 32 Canadian vessels crossed over to the Russian side after having completed their coast catch. In addition, there seems to have been 5 British schooners sailing from Japan, consequently altogether 37 British vessels. To these must be added a few American schooners, of which I have no detailed account at hand. Capt. Charles Lutjens, in the *Kate and Anna*, caught about 150 seals "between from 40 to 100 miles south of the Commander Islands, and these were seized and confiscated" (Fur Seal Arb., VIII, p. 714). The *Henry Dennis* obtained 189 seals, as detailed elsewhere in this report.

These facts are shown in more detail in the following table, which is extracted from the record of the entire British Columbia sealing fleet, as given in the Twenty-fifth Annual Report of the Canadian Department of Marine and Fisheries (pt. II, pp. 60–61).

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[1] The British Bering Sea commissioners, writing in June, 1892, could therefore state as a "fact that pelagic sealing, as understood on the coast of America, is there [Asiatic coast] practically unknown." It is probable, however, that the real beginning was made already in 1891, though on a small scale. Capt. Chas. Lutjens, of San Francisco, owner of the schooner *Kate and Anna*, states (Fur Seal Arb., VIII, p. 715) that on going into Bering Sea on June 6, 1891, he was warned out, and went directly to the Russian side, where he got 450 seals. The *Penelope*, Capt. J. W. Todd, of Victoria, was also there that year; also *Beatrice*, Capt M. Keefe, who got 500 seals there; *Umbrina*, Capt. J. Matthews, 30 seals; *Maud S.*, Capt. A. McKeil, and probably several others.

Report of British Columbia sealing fleet sealing in "Asiatic" waters in the season of 1892.

Schoonor.	Lower coast catch.	Upper coast catch.	Asiatic catch.	Total.
Annio E. Paint	186	412	421	1, 019
Annic C. Moore	64	379	447	990
Arietis	....	418	738	1, 156
Agnes McDonald	....	591	373	964
Brenda	....	409	512	921
Carlotta G. Cox	436	1, 605	696	2, 737
C. H. Tupper	308	967	542	1, 817
Carmolite	174	705	(seized.)	879
C. D. Rand	28	....	(seized.)	28
Dora Sicwerd	....	224	673	897
E. B. Marvin	183	1, 434	430	2, 045
Enterprise	....	....	507	507
Favourite	....	450	202	652
Geneva	270	420	600	1, 290
Henrietta	44	108	(seizod.)	152
Maria	....	....	(seized.)	....
Mascot	107	220	119	446
Maud S	185	769	748	1, 702
May Belle	149	145	230	524
Schooner.	**Lower coast catch.**	**Upper coast catch.**	**Asiatic catch.**	**Total.**
Mary Ellen	35	507	304	846
Mermaid	....	164	238	402
Mountain Chief	....	....	(seized.)	....
Ocean Belle	128	687	646	1, 461
Oscar and Hattie	25	186	261	(seized.) 472
Penelope	345	....	1, 362	1, 707
Rosie Olsen	....	....	(seized.)	....
Sea Lion	472	629	833	1, 934
Sadie Turpie	....	451	244	695
Teresa	83	306	175	564
Thistle (str.)	79	....	4	83
Triumph	....	284	257	541
Umbrina	143	707	623	1, 473
Victoria	23	....	558	581
W. P. Sayward	180	....	900	1, 080
Walter A. Earle	100	1, 226	541	1, 866
Walter L. Rich	....	182	204	386
W. P. Hall	....	....	416	416

The total catch by the Canadians alone amounted to about 17,000 skins.[1] Out of this number probably no less than 14,000 were skins of female seals. Adding to this the number of seals killed, but lost, those captured by the United States schooners, and those shot during the northward migration during the spring of that year, it is easy to eonceive how enormous and irreparable must have been the blow inflicted upon the *breeding* seals of the Commander Islands during the year 1892.

With over 40 vessels scouring the seas around the islands, their boats and canoes following the female seals as they went to and from the feeding-grounds, no wonder that the latter were diseovered by the sealers, and in these places undoubtedly most of the damage was done.

But not all the schooners were satisfied with taking the seals outside of the territorial wateis of Russia; they adopted the taeties of sending the boats inshore to hunt off the rookeries, and as a consequence many of them had to feel the claws of the bear. The Russian authorities, evidently in antieipation of what would happen, had several eruisers patrolling her seas, and no less than seven schooners, one hailing from the United States and the other six owing allegiance to Great Britain, were eaptured by the commanders of the cruisers *Zabiaka*, Captain de Livron, and *Vitiaz*, Captain Zarine, and by Mr. Grebnitski on board the eompany's steamer *Kotik*. The sehooners were taken to Vladivostok, eondemned, and sold, except the *Rosie Olsen*, which was rechristened the *Prize* and given to Capt. W. Copp, of the *Vancouver Belle*, on condition that he take 37 of the eaptured sailors to British Columbia. The other sailors were sent home in the American ship *Majestic*, exeept the men of the sehooners *Marie* and *Carmolite*, who were taken to Vladivostok and then shipped to Japan.

The sehooners, whose eapture created a great exeitement in Canadian sealing eireles, were as follows:

(1) *C. H. White*, of San Franeiseo, seized by the *Zabiaka* July 16, between Copper Island and Bering Island.

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[1] Total of the "Asiatic catch" in the above table 14, 804
Seized by Russian war vessels 2, 418

Total.. 17, 222

Some of the skins seized by the Russians were taken on the Northwest coast.

(2) *Willie McGowan*, of Shelburne, N. S., seized by the *Zabiaka* July 18,[1] about 18 miles[2] southwest of Palata, Copper Island.

(3) *Rosie Olsen*, of Victoria, B. C., seized by Mr. Grebnitski, July 26, in 55° 23′ north latitude and 165° 27′ east longitude, or about 10 miles northwest of Zapadni Mys, Bering Island.

(4) *Ariel*, of Victoria, B. C., seized by the *Zabiaka*, on July 28, apparently about 10 miles southwest of the Copper Island rookeries.[3]

(5) *Vancouver Belle*, of Vancouver, seized by the *Zabiaka*, on August 12, about 17 miles south of the southern extremity of Copper Island.

(6) *Marie*, of Maitland, N. S., seized by Mr. Grebnitski, August 21, in 54° 36′ north latitude and 168° 24′ east longitude, or about 9[4] miles northeast from the south end of Copper Island, the nearest land.

(7) *Carmolite*, of Vancouver, seized by the *Vitiaz* (with Admiral S. O. Makarof on board), August 29, in 54° 29′ north latitude and 168° 2′ east longitude, about 6 miles[5] southeast of the isthmus (Peresheyek) of Copper Island.

In addition, (1) one boat and crew belonging to the schooner *Marvin* were seized by the natives on one of the Copper Island rookeries for killing seals. (2) Three boats and crews having clubbed seals on the rookeries were captured by the *Zabiaka* on July 21, 9 miles from the southern extremity of Copper Island; they belonged to the schooner *Sayward*. (3) Two boats and 6 sailors from the *Annie C. Moore* were caught on one of the rookeries by the natives.

The number of skins taken from the British schooners was as follows:

Name of vessel.	No. of skins.
Marie	622
Rosie Olsen	379
Carmolite	608
Vancouver Belle	594
W. McGowan	76
Ariel	139
Total	2,418

The confiscated skins were sold by auction, part in Petropaulski, part in London.

The prize moneys from the sale of the schooners and outfits were distributed among the captors.

It will be seen that all of the British schooners were captured outside of the 3-mile limit, and diplomatic remonstrances and claims for damages were at once made by Great Britain. The Russian Government appointed a special commission to investigate the seizures, and found that the *Marie*, *Rosie Olsen*, *Carmolite*, and *Vancouver Belle* were properly seized, as their boats had been sealing in territorial waters, while

[1] By some mistake the date is given as June 6 in the report of the Russian commission as rendered in the 26 Ann. Rep. Canad. Dept. Fish., p. CLIX. July 6, old style, is probably intended.

[2] In the same report the distance from the coast is given as 21 miles, although the position is said to have been 54° 21′ north latitude and 167° 43′ east longitude, which is a trifle more than 18 miles from the nearest point of Copper Island.

[3] The positions and distances in the report quoted above are so contradictory that it is hard to tell which is meant to be correct. Thus, in the present case, it is stated (p. CLIX) that "The schooner *Ariel* was seized by the cruiser *Zabiaka* on the 16th July [old style] at 3.30 a. m., in 54° 31′ north latitude and 167° 40′ east longitude. At the time of the seizure she was making away from the coast under easy sail, and was 21 miles from Copper Island." Of course both statements can not be correct.

[4] Seven in the report above referred to.

[5] Eight miles according to the above report.

the proof that the *Willie McGowan* and *Ariel*, or their boats, had been sealing inside the 3-mile limit was considered insufficient. The findings of the commission are rendered in detail in the Twenty-sixth Annual Report of the Canadian Department of Fisheries.

The experience of 1892 was conclusive proof that it was feasible for the schooners to stay 20 miles away from the islands and yet send in their boats to the rookeries to prey upon the breeding seals going to and fro. It was also made plain that there would be very little chance of stopping the traffic by means of large cruisers patrolling the sea. The Russian authorities, therefore, were very anxious to establish a prohibitive zone around the islands wide enough to make it impossible for the boats to raid the rookeries independently, the mere presence of the schooner inside of this limit being evidence of illegal sealing. Negotiations were progressing during the winter of 1892 and 1893 between the two governments, and finally, in May, 1893, a provisional agreement was entered into between Russia and Great Britain establishing a protective zone of 30 miles around the Commander Islands and Robben Island. It is evident that the Russian authorities at that time were unaware of the fact that the great bulk of the skins taken by the British Columbia sealing fleet were obtained on the feeding-grounds of the breeding females, and were also ignorant of the exact location of these grounds, or they would not have rested satisfied with the zone of 30 miles, which has been of but very little protective value to the seals. In view of the rôle which the Russian acceptance of this 30-mile zone played in the establishment of the 60-mile zone around the Pribylof Islands, it is important to remember that in accepting the *30-mile zone* the Russians had a much more limited *object* in view, viz, *to make it impossible for the pelagic sealers to raid the rookeries.*

THE PROVISIONAL AGREEMENT OF MAY, 1893.

The provisional arrangement, which was to be entirely without retroactive force as regards the British vessels seized in 1892, is as follows:

I. During the year ending December, 1893, the English Government will prohibit their subjects from killing or hunting seal within a zone of 10 marine miles on all the Russian coasts of Behring Sea and the North Pacific Ocean, as well as within a zone of 30 marine miles around the Komandorsky Islands and Tulènew (Robben Island).

II. British vessels engaged in hunting seals within the aforesaid zones, beyond Russian territorial waters, may be seized by Russian cruisers, to be handed over to British cruisers or to the nearest British authorities. In case of impediment or difficulty, the commander of the Russian cruiser may confine himself to seizing the papers of the aforementioned vessels, in order to deliver them to a British cruiser or to transmit them to the nearest British authorities on the first opportunity.

III. Her Majesty's Government engage to bring to trial before the ordinary tribunals, offering all necessary guaranties, the British vessels which may be seized as having been engaged in sealing within the prohibited zones beyond Russian territorial waters.

IV. The Imperial Russian Government will limit to 30,000 the number of seals which may be killed during the year 1893 on the coasts of the islands of Komandorsky and Tulènew (Robben Island).

V. An agent of the British Government may visit the aforementioned islands (Komandorsky and Tulènew) in order to obtain from the local authorities all necessary information on the working and results of the agreement arrived at, but care should be taken to give previous information to these authorities of the place and time of his visit, which should not be prolonged beyond a few weeks.

VI. The present arrangement has no retroactive force as regards British vessels captured previously by the cruisers of the Imperial Russian Marine.

The British Parliament enacted the necessary legislation (Seal Fishery, North Pacific, Act 1893), an "order in council" was passed July 4, 1893, and the agreement went into effect. The Russian war vessels the *Zabiaka* and the *Yakut*, the latter a small transport, as well as two British cruisers, kept up a constant patrol of the 30-mile zone.

The success of 1892 and the continued closure of the American side of Bering Sea during 1893 drove the great majority of the sealing fleet over to the Asiatic side early in the season, and the Commander Islands herd was, therefore, preyed upon to a previously unknown extent along the Japan coast during the migration, in addition to the slaughter of the females on the feeding-grounds. No less than 35 schooners from Victoria, B. C., were sealing off the Commander Islands, mostly outside the 30-mile limit, and made a haul of 12,013 skins, while 22 schooners had hunted off the Japan coast, obtaining a total of 29,270 skins. It is stated that, in addition to the above figures relating to the Canadian fleet, the number of skins landed at Hakodate, Japan, by American vessels was 18,587, and by Hawaiian vessels 3,212, a total of 21,799 skins. A small percentage of these was undoubtedly contributed by the Kuril herd and Robben Island seals, but it is safe to say that the pelagic sealing of 1893 yielded about 60,000 Commander Island skins, the majority females. How many more were wastefully killed and lost it is impossible to say.

I append a list of the Canadian vessels sealing on the Asiatic side in 1893, extracted from the Twenty-sixth Annual Report of the Canadian Department of Fisheries (pp. CLXVI–CLXVII), as follows:

Report of vessels of British Columbia sealing fleet sealing on the "Russian side," season 1893.

Vessels.	Tons.	Crews.		Boats.	Canoes.	Masters.	Catch.	
		White.	Indian.				Japan coast.	Russian side.
Victoria, B. C.:								
Triumph	98	7	28	4	14	C. N. Cox		623
Sapphire	108	8	26	12	3	Wm. Cox		341
E. B. Marvin	117	27		8		J. Gould		517
Mascot	40	7	14	2	7	H. F. Siewerd		327
Dora Siewerd	94	24		7		R. O. Lavender		434
Minnie	46	5	20	2	10	J. Mohrhouse		20
Annie E. Paint	82	23		8		A. Bissett		401
Diana	50	19		6		A. Nelson		294
Mermaid	73	23		8		W. H. Whiteley	940	315
Fawn	59	3	21	2	10	L. Magnesen		77
Ocean Belle	83	25		8		T. O'Leary		547
Arietis	86	23		7		A. Douglass	920	464
Ainoko	75	5	14	1	7	G. Heater		46
Katharine	82	6	19	2	9	W. D. McDougall		363
Enterprise	69	24		7		J. W. Todd	1,027	274
Agnes McDonald	107	25		7		M. F. Cutler	2,333	433
Viva	92	23		6		J. W. Anderson	1,441	30
Umbrina	98	24		7		C. Campbell	1,827	625
Vera	60	19		5		W. Shields	1,910	99
Otto	86	8	24	2	12	M. Keefe		397
Mary Taylor	42	18		5		E. Shields		240
Brenda	100	26		8		C. E. Locke		408
Libbie	93	23		7		F. Hackett	1,242	389
City of San Diego	46	14		5		M. Pike	942	101
Geneva	92	26		8		W. O'Leary	1,612	454
Casco	63	19		6		O. Buckley	1,473	199
Carlotta G. Cox	76	24		7		W. D. Byers	2,396	376
Oscar and Hattie	81	24		7		W. E. Baker	1,178	1,020
Teresa	63	20		6		E. Lorenz	677	147
Sadie Turpie	56	24		7		C. Le Blanc	927	475
Maud S	97	24		7		R. E. McKeil	989	58
Mary Ellen	63	23		7		W. O. Hughes	1,573	406
Walter L. Rich	76	24		7		S. Balcom		517
Annie C. Moore	113	26		8		J. Daley	822	333
Walter P. Hall	98	23		7		J. B. Brown	768	263

Wise by experience, the sealing fleet kept pretty well outside the 30-mile zone, though the following seizures of British vessels were made:

(1) *Minnie*, of Victoria, British Columbia, seized by the *Yakut*, July 17, 21 miles southeast of Copper Island.

(2) *Ainoko*, of Victoria, British Columbia, seized by the *Yakut*, July 22, 16 miles south of Copper Island.

(3) *Maud S.*, of Victoria, British Columbia, seized by the *Yakut*, August 29, 22 miles southwest of Copper Island.

(4) *Arctic*, of Shanghai, seized by the *Zabiaka* within the 30-mile zone.

Of these, only the *Minnie* was afterwards condemned.

The provisional agreement as given above was renewed in 1894 and 1895 for those years. Owing to the threatening political aspects, as a consequence of the Japanese-Chinese war, the Russian Government had only one ship patrolling the 30-mile limit in 1895. The British cruiser *Caroline* did patrol duty early in the season, and was relieved by the *Porpoise*, Captain Francis R. Pelly, commanding. No seizures were made in that year.

As schooners flying the flag of the United States were also among the fleet preying upon the Commander Islands herd, it was found necessary to establish a *modus vivendi* with the United States similar to the provisional agreement with Great Britain. An arrangement, differing only in a few verbal changes from the latter, was drawn up by the Imperial Minister for Foreign Affairs, Mr. Giers, and signed in Washington by the representatives of the respective governments on May 4, 1894. The exact text of this arrangement, which "shall only be in force until further orders," is found in Executive Document No. 67, Senate, Fifty-third Congress, third session, being the President's Message regarding the Enforcement of Regulations respecting Fur Seals, p. 82.

The Twenty-seventh Annual Report of the Canadian Department of Fisheries contains an account of the Canadian pelagic sealing operations on the Asiatic side during 1894, by Mr. R. N. Venning, from which we quote the following abstracts:

> The vessels this year operating in the vicinity of the Russian Seal Islands are reported to have kept well outside the protective zone, principally working about 100 miles southeast of Copper Island. As a consequence, the present year's operations are marked by an almost total absence of interference with the Canadian fleet by Russian authorities.
>
> The only instance reported is that of a sealing boat of the schooner *May Belle*, of Victoria, B. C., manned by Joseph Morrell, Charles K. Leclaire, and James Costin, which lost the vessel in a fog, and after remaining out all night and failing to find the schooner on the following morning, the occupants, fearing a storm which was threatening, made for the shore of Copper Island for shelter. They were discovered and arrested before landing.
>
> The boat and her equipment were retained at Copper Island and the three men were taken to Petropaulovski, on the mainland of Kamchatka, where, after a detention of 32 days, they were handed over to Her Majesty's ship *Daphne*, taken to Yokohama, Japan, and delivered to Her Majesty's consul at that port.
>
> They were imprisoned, but released some four hours later, and informed by the consul that the charge against them was not sufficient for their detention. They were accordingly sent by Her Majesty's consul to Victoria, B. C., by Canadian Pacific Railway steamship, where they arrived on the 20th November, 1894.
>
> Claims for damages have been filed by the parties and by the owners of the sealing boat, and representations have been made to Her Majesty's government on the subject.

Report of vessels of British Columbia sealing fleet in the vicinity of Copper Island, season 1894.
[From 27 Ann. Rep. Canada Dept. Fish.]

Vessels.	Tons.	Crews.		Boats.	Canoes.	Masters.	Catch.	
		White.	Indian.				Japan coast.	Vicinity Copper Island.
Victoria:								
Enterprise	69	22		8		O. Scarf	1,254	314
Rosie Olsen	39	6	16	2	8	A. B. Whidden	1,043	
Umbrina	99	25		8		C. Campbell	2,588	153
Oscar and Hattie	81	24		7		A. Folger	1,733	176
Diana	50	19		6		A. Nelson	1,961	433
Brenda	100	26		8		C. E. Locke	2,383	343
Arietis	86	25		8		A. Douglass	1,197	
Casco	63	22		6		O. Bucholz	1,926	
Dora Siewerd	94	26		8		F. Cole	2,584	
Walter A. Earle	68	8	20	2	10	L. Magnesen	1,471	
Fawn	59	6	18	1	9	M. Keefe	911	
Agnes McDonald	107	26		8		M. Cutler	1,707	471
W. P. Hall	99	24		7		J. B. Brown	710	
Mermaid	73	25		8		W. H. Whiteley	1,603	505
City of San Diego	46	16		5		M. Pike	1,304	250
Mary Taylor	43	19		5		E. Robins	874	250
Libbie	93	22		7		F. Hackett	1,010	200
May Belle	58	14		6		E. Shields	925	197
Mary Ellen	63	23		7		W. O. Hughes	1,909	86
Viva	92	26		7		J. Anderson	1,437	
W. P. Sayward	60	20		6		G. Ferey	606	35
Penelope	70	20		7		L. McGrath	1,306	296
Vera	60	19		6		W. S. Shields	1,075	
Carlotta G. Cox	76	24		7		W. Byers	1,947	
Otto	86	25		8		J. McLeod	1,014	623
E. B. Marvin	96	23		7		C. J. Harris	2,118	
Annie E. Paint	82	26		9		A. Bassett	1,497	531
Geneva	92	27		9		W. O'Leary	1,092	558
Teresa	63	25		7		F. Gilbert	1,102	120
Ocean Belle	83	22		6		T. O'Leary	530	274
Sadie Turpie	56	22		8		C. Leblanc	1,783	171
Maud S.	97	24		8		R. McKiel	1,343	86
Aurora	41	18		5		H. J. Lund	693	21
Florence M. Smith	99	27		8		J. Allen	96	81
Mascot	40	4	16	1	7	H. F. Siewerd	558	
Pioneer	66	24		6		W. E. Baker		1,263
Vancouver:								
Beatrice	49	21		6			1,703	
United States:								
Louis Olsen							435	
Anna Matilda							7	
Josephine							48	
Total							49,483	7,437

The pelagic sealing seasons of 1894 and 1895 are most notable for the excessive number of skins taken during the migration and for the falling off in the catch on the Copper Island feeding-grounds, indicating the approaching exhaustion of this locality. But, in addition, the latter year is notable for being the first year in which pelagic sealers have to any extent attacked the feeding-grounds of the Bering Island rookeries.

It has been long known that seals occurred in summer in the waters northwest of Bering Island, from Cape Kamchatka to Karaginski Island; but it seems as if in 1895 the sealers repaired there systematically and with success. I am indebted to Mr. C. H. Townsend for this information and for the following abstracts of the logs of the schooners *Ida Etta*, sealing off Cape Nagikinski, and *Jane Grey*, sealing off Cape Afrika.

Schooner Jane Grey.

Date.	Location.	Seals.
1895.		
Aug. 16	56° 44′ N. 164° 25′ E.	28
Aug. 17	56° 09′ N. 164° 10′ E.	8
Aug. 18	56° 09′ N. 164° 10′ E.	2
Aug. 19	56° 09′ N. 164° 10′ E.	1
Aug. 20	56° 09′ N. 164° 10′ E.	13
Aug. 21	56° 09′ N. 164° 10′ E.	13
	Total	65

Schooner Ida Etta.

Date.	Location.	Seals.
1895.		
Aug. 20	Cape Nagikinski, SW. 30 miles	37
21	Cape Nagikinski, SW. 20 miles	35
24	Cape Nagikinski, SW. 20 miles	28
26	Cape Nagikinski, SW. 20 miles	28
27	Cape Nagikinski, W. 30 miles	10
31	Cape Nagikinski, W. 30 miles	3
Sept. 1	Cape Nagikinski, WSW. 25 miles	25
2	Cape Nagikinski, SW. 20 miles	6
3	Cape Nagikinski, SW. 30 miles	4
4	Cape Nagikinski, SW. 25 miles	4
	Total	180

I am also indebted to Mr. Townsend for figures relating to the catch of 1894, and for the information that the total Japan coast catch for 1895 amounted to 31,048 skins, and total catch of the pelagic sealers in Russian waters 7,684 skins; together, 38,732 skins. The Commander Islands herd, therefore, lost in 1895 no less than 35,000 seals, the majority females, besides the unknown number killed without being captured.[1]

During the five years 1891 to 1895, inclusive, the "Asiatic catch" by pelagic sealers may be summed up as follows:

Year.	Nationality of vessels.	Japan catch.	Russian catch.	Totals.	Grand totals.
1891					*5, 847
1892	Canada	(?)	17, 222		†26, 752
	United States	(?)	1, 224		
1893	Canada	29, 270	12, 013	41, 283	63, 082
	United States and Hawaii			21, 799	
1894	Canada	49, 483	7, 437	56, 920	90, 067
	United States	31, 376	1, 771	33, 147	
1895	Canada	18, 686	6, 605	25, 291	[1]38, 732
	United States	12, 362	1, 079	13, 441	

* From the report of Hon. Charles S. Hamlin, Assistant Secretary, U. S. Treasury (Doc. 137, Senate, Fifty-fourth Cong., 1st sess., pt. 1, p. 6). During that year 18,000 skins are recorded from "undetermined localities," some of which are probably "Asiatic" in their origin.

† This total is derived from Mr. Hamlin's report (*l. c.*). The "Japan catch" of 1892 was therefore over 8,300.

It will be seen that the known pelagic "Asiatic catch" from 1892–95 was over 218,000 skins. Allowing the 8,000 skins for the Kurils and Tiuleni, the *known* loss in that period to the Commander Islands herd was about 210,000 seals, apart from the loss of wounded ones, etc. The number of seals killed on the islands in the same period was 105,236. The pelagic *catch* was therefore twice as large as that on the islands, while the loss to the herd from that cause was much greater. It is certainly no exaggeration to say that *the actual loss to the herd in those four years has averaged 100,000 a year, one-half of which were probably females, while even in the palmiest days of exclusive land sealing the loss only averaged 50,000 seals a year, all males.*

To illustrate and complete this chapter on pelagic sealing I have had plotted on map 1 the position of 11 schooners off the Commander Islands during the sealing season. The positions for each noon are connected by straight lines and the figures represent the number of seals taken during the preceding 24 hours. Extracts from the log books are appended herewith. The logs are given *in extenso* in the Fur Seal Arbitration case, except that of the *Henry Dennis*, for which I am indebted to Mr. Townsend.

[1] Mr. Townsend has since informed me that the loss to the Commander Island herd is to be increased by at least 10,000 seals, as shown by reports from consuls, etc., recently received.

Catch of seal skins on board of British schooner Umbrina, 1892.

Date.	Latitude.	Longitude.	Remarks.	Daily catch.	Totals.
1892.	° ′	° ′			
July 20	53 50 N.	167 30 E.	Killed from schooner	2	855
22	53 50 N.	167 30 E.	....do	1	856
23	53 40 N.	167 10 E.	....do	1	857
24	53 40 N.	166 40 E.	Boats out all day	17	874
25	53 50 N.	167 00 E.		12	886
26	53 40 N.	166 30 E.		65	951
27	53 30 N.	166 25 E.		68	1,019
28	53 40 N.	166 50 E.		27	1,046
Aug. 1	53 30 N.	166 50 E.		3	1,049
2	53 40 N.	166 55 E.		10	1,059
3	53 34 N.	166 40 E.		8	1,097
4	53 40 N.	165 30 E.		65	1,132
5	53 45 N.	165 10 E.		72	1,204
6	53 55 N.	165 10 E.		56	1,260
7	54 10 N.	165 30 E.		10	1,270
10	53 40 N.	166 30 E.	Killed from schooner	1	1,271
11	53 47 N.	166 40 E.		5	1,276
12	53 40 N.	166 50 E.	Killed from schooner	1	1,277
16	53 55 N.	167 00 E.		8	1,285
17	55 55 N.	166 50 E.		21	1,306
18	53 30 N.	166 45 E.		25	1,331
19	53 40 N.	166 40 E.	Killed from schooner	1	1,332
21	53 35 N.	166 35 E.		15	1,347
22	53 35 N.	166 45 E.		55	1,402
23	53 50 N.	166 35 E.	Killed from schooner	2	1,404
24	54 00 N.	166 35 E.		62	1,466
25	53 50 N.	166 30 E.	Killed from schooner	1	1,467
26	54 00 N.	166 35 E.	....do	1	1,468
30	53 35 N.	166 30 E.	....do	2	1,470
31	53 30 N.	166 40 E.	....do	3	1,473
				620	

Extract of return showing the dates on which seals were taken, the number taken each day, and the noon position on each such dates, of the schooner Maud S. on her sealing voyage for the season 1892.

Date.	No. of seals taken.	Latitude.	Longitude.
1892.		° ′	° ′
July 14	11	53 10 N.	166 10 E
15	10	53 33 N.	166 55 E.
21	10	53 33 N.	165 29 E.
22	12	53 12 N.	165 46 E.
23	7	52 49 N.	167 22 E.
26	1	53 24 N.	166 36 E.
27	57	53 24 N.	168 04 E.
28	99	53 21 N.	168 08 E.
28	14	53 33 N.	168 09 E.
Aug. 2	3	54 10 N.	167 11 E.
3	8	53 55 N.	166 45 E.
4	12	53 50 N.	166 59 E.
5	40	53 44 N.	167 04 E.
6	41	53 35 N.	166 01 E.
7	71	53 33 N.	165 51 F.
8	3	53 35 N.	165 49 E.
10	24	54 11 N.	167 00 E.
11	12	53 04 N.	166 40 E.
13	5	53 53 N.	165 14 E.
14	2	54 43 N.	164 58 E.
17	15	56 48 N.	166 15 E.
18	8	56 35 N.	167 25 E.
19	2	55 39 N.	167 57 E.
21	1	53 48 N.	169 10 E.
22	7	53 22 N.	168 02 E.
23	114	52 51 N.	167 45 E.
25	16	52 46 N.	167 35 E.
26	16	52 44 N.	167 58 E.
27	7	52 55 N.	167 34 E.
31	31	52 52 N.	167 38 E.
Sept. 4	12	53 15 N.	167 26 E.
5	30	53 14 N.	167 38 E.
6	1	53 01 N.	167 08 E.
7	34	53 06 N.	167 08 E.
10	9	52 31 N.	167 19 E.
	745		

Extract of return showing the dates on which seals were taken, the number taken each day, and the noon position on each such dates, of the schooner Vancouver Belle on her sealing voyage for the season 1892.

Date.	No. of seals taken.	Latitude.	Longitude.
1892.		° ′	° ′
July 4	3	54 11 N.	168 52 E.
5	2	54 05 N.	167 15 E.
8	1	54 04 N.	167 00 E.
9	18	54 12 N.	169 03 E.
10	2	54 16 N.	169 32 E.
13	3	54 13 N.	169 30 E.
14	22	54 10 N.	168 30 E.
16	1	55 25 N.	167 20 E.
17	1	55 40 N.	166 10 E.
20	1	55 16 N.	163 24 E.
25	8	55 28 N.	170 24 E.
26	2	55 09 N.	169 08 E.
27	8	53 56 N.	169 08 E.
28	103	54 05 N.	167 35 E.
29	11	54 05 N.	167 35 E.
30	1	54 07 N.	167 00 E.
31	1	54 15 N.	167 00 E.
Aug. 1	13	54 04 N.	167 10 E.
2	1	54 10 N.	167 10 E.
3	13	54 20 N.	167 33 E.
4	5	54 12 N.	167 26 E.
5	14	53 54 N.	167 35 E.
6	24	54 10 N.	167 38 E.
7	31	54 13 N.	167 20 E.
8	1	54 20 N.	167 01 E.
10	3	54 20 N.	166 06 E.
11	3	54 15 N.	166 30 E.
	296		

Extract of return showing the dates on which seals were taken, the number taken each day, and the noon position on each such dates, of the schooner Beatrice (Vancouver) on her sealing voyage for the season 1892.

Date.	No. of seals taken.	Latitude.	Longitude.	Total seals to date.
1892.		° ′	° ′	
July 24	1	51 54 N.	168 56 E.	....
25	3	53 17 N.	167 48 E.	....
26	68	54 17 N.	167 40 E.	....
27	112	53 54 N.	167 56 E.	....
28	49	53 38 N.	167 30 E.	907
Aug. 1	4	53 28 N.	167 01 E.	....
2	15	53 29 N.	168 15 E.	....
3	28	53 50 N.	167 18 E.	....
4	28	53 23 N.	168 15 E.	....
5	47	53 36 N.	167 34 E.	....
6	75	53 26 N.	167 36 E.	....
7	8	53 22 N.	166 07 E.	....
9	12	53 45 N.	166 20 E.	....
10	5	53 24 N.	165 52 E.	....
11	7	54 07 N.	165 31 E.	....
16	12	53 21 N.	166 37 E.	....
17	15	53 18 N.	167 04 E.	....
18	14	53 10 N.	167 21 E.	....
21	9	53 36 N.	169 29 E.	....
22	27	53 19 N.	169 00 E.	....
23	5	53 29 N.	169 04 E.	....
24	21	54 06 N.	168 17 E.	....
25	1	53 32 N.	168 12 E.	....
	536			

Extract of return showing the dates on which seals were taken, the number taken each day, and the noon position on each such dates, of the schooner Arietis on her sealing voyage for the season 1892.

Date.	No. of seals taken.	Latitude.	Longitude.	Total seals to date.
1892.		° ′	° ′	
July 21	1	54 08 N.	169 00 E.	480
22	25	53 48 N.	169 30 E.	505
25	21	53 30 N.	169 00 E.	526
26	16	53 00 N.	168 45 E.	542
27	160	53 20 N.	169 00 E.	702
28	17	54 00 N.	168 45 E.	719
29	1	54 00 N.	168 55 E.	720
31	5	54 10 N.	168 30 E.	725
Aug. 1	3	54 00 N.	169 00 E.	728
2	5	53 45 N.	168 45 E.	733
3	13	53 40 N.	168 30 E.	746
4	118	53 20 N.	168 15 E.	864
5	154	53 20 N.	168 20 E.	1,038
7	16	53 40 N.	168 45 E.	1,054
8	3	54 00 N.	168 00 E.	1,057
9	4	54 00 N.	168 30 E.	1,061
10	3	53 45 N.	168 00 E.	1,064
18	14	53 00 N.	169 00 E.	1,078
22	25	52 30 N.	167 40 E.	1,103
24	40	53 00 N.	168 00 E.	1,143
29	6	53 00 N.	169 00 E.	1,149
	650			

Extract of return showing the dates on which seals were taken, the number taken each day, and the noon position on each such dates, of the schooner Agnes McDonald on her sealing voyage for the season 1892.

Date.	No. of seals taken.	Latitude.	Longitude.	Total seals to date.
1892.		° ′	° ′	
July 26	18	52 38 N.	168 02 E.	608
27	97	52 48 N.	168 08 E.	705
28	26	52 49 N.	168 00 E.	731
Aug. 1	12	53 30 N.	167 35 E.	743
2	54	53 52 N.	167 05 E.	797
3	17	53 49 N.	167 02 E.	814
4	24	54 03 N.	166 17 E.	838
5	6	54 07 N.	165 05 E.	844
6	4	54 18 N.	165 45 E.	848
7	4	54 05 N.	166 35 E.	852
9	5	54 07 N.	167 15 E.	857
10	3	54 02 N.	167 42 E.	860
11	11	53 42 N.	165 37 E.	871
17	11	53 43 N.	168 02 E.	882
18	18	53 12 N.	165 25 E.	900
20	3	53 05 N.	166 10 E.	903
21	8	52 45 N.	166 58 E.	911
22	52	53 20 N.	167 42 E.	963
25	1	52 28 N.	166 44 E.	964
	374			

Extract of return showing the dates on which seals were taken, the number taken each day, and the noon position on each such dates, of the schooner Henry Dennis on her sealing voyage for the season 1892.

Date.	No. of seals taken.	Latitude.	Longitude.
1892.		° ′	° ′
Aug. 1	1	56 37 N.	168 30 E.
3	13	56 40 N.	168 38 E.
4	40	56 27 N.	168 13 E.
5	108	56 20 N.	168 07 E.
6	26	56 37 N.	168 10 E.
7	1	56 43 N.	167 50 E.
	189		

Extract of return showing the dates on which seals were taken, the number taken each day, and the noon position on each such dates, of the schooner Annie E. Paint on her sealing voyage for the season 1892.

Date.	No. of seals taken.	Latitude.	Longitude.	Total seals to date.
1892.		° ′	° ′	
Aug. 3	5	52 55 N.	166 40 E.	569
4	3	52 32 N.	166 01 E.	572
5	24	53 04 N.	165 21 E.	596
6	46	52 30 N.	165 30 E.	642
8	53	52 47 N.	165 37 E.	695
12	15	53 00 N.	166 40 E.	710
17	8	53 02 N.	166 46 E.	718
19	33	52 59 N.	166 31 E.	751
21	8	52 48 N.	166 12 E.	759
22	26	52 58 N.	166 14 E.	784
23	48	52 59 N.	166 25 E.	832
27	32	52 58 N.	166 35 E.	864
31	13	52 01 N.	167 00 E.	878
Sept. 5	16	53 00 N.	167 30 E.	894
12	28	53 00 N.	165 58 E.	922
13	19	52 59 N.	165 40 E.	941
20	44	52 00 N.	169 11 E.	985
	421			

Extract of return showing the dates on which seals were taken, the number taken each day, and the noon position on each such dates, of the schooner W. P. Hall on her sealing voyage for the season 1892.

Date.	No. of seals taken.	Latitude.	Longitude.
1892.		° ′	° ′
July 21	6	54 25 N.	170 00 E.
24	5	54 35 N.	169 10 E.
27	59	54 30 N.	168 50 E.
Aug. 2	19	54 20 N.	168 40 E.
3	15	54 03 N.	168 55 E.
4	40	53 35 N.	168 40 E.
5	49	53 30 N.	169 00 E.
6	36	54 05 N.	168 30 E.
8	20	54 35 N.	168 55 E.
9	40	54 25 N.	169 00 E.
10	10	54 05 N.	168 35 E.
11	27	54 10 N.	168 55 E.
21	8	53 00 N.	169 35 E.
22	30	52 55 N.	169 00 E.
27	2	52 20 N.	168 30 E.
	366		

V.—CONCLUSIONS.

SUMMARY.

To gain a clear understanding of the fur-seal question, in so far as it relates to the Russian Seal Islands, it may be well to sum up the essential points as follows:

The topographical character of the rookeries on Bering Island and on Copper Island are essentially different. On the former the grounds are low and accessible, and the drives are unusually easy, involving but little hardship on the seals, even compared with the rookeries on St. Paul Island, Pribylof group. On Copper Island, however, the rookeries are situated at the base of high precipices, very difficult of access, and the drives, from the mountainous nature of the island, are as harsh and trying as it is possible to imagine.

Notwithstanding this difference in the topography, the conditions of seal life on the rookeries were practically alike on both islands previous to, during, and some time after my first visit to the islands in 1882–83. It is an indisputable fact that the seals were increasing markedly in number during that period on both islands.

Of late years the seals have been rapidly decreasing on both islands, the decrease corresponding to the same phenomenon on the Pribylof Islands, but taking place proportionately about five years later on an average.

When I again visited the islands, in 1895, I found the conditions of seal life on the rookeries had so changed as to radically differ on the two islands. On Bering Island, in addition to a marked decrease in killables, there was a notable scarcity of old bulls, while the decrease in breeding females was less apparent. On Copper Island, while the number of killables was small, sexually mature male seals were, on the contrary, plentiful, and at the same time the number of females had decreased enormously.

Prior to 1892 the Commander Islands seals had suffered but little from pelagic sealing in general and practically nothing from preying upon the feeding-grounds of the female seals, at the very time when the Pribylof Island sealing-grounds were being rapidly exhausted.

Since 1892 the whole body of the pelagic sealing fleet has preyed, during the most precarious season of seal life, largely upon the female seals visiting the feeding-grounds off Copper Island.

An unusual mortality of starving seal pups has not been observed until last year on Bering Island, but the natural conditions of the Copper Island rookeries are such as to make it easy to overlook such a fact.

The 30-mile zone stipulated in the Russian-British arrangement of 1893 has only put a stop to the raiding of the rookeries, but has been found utterly valueless as a protective measure against pelagic sealing.

The rookeries of the Commander Islands will become exhausted within a few years if the present conditions are allowed to continue much longer.

CAUSES OF THE DECREASE.

Three different causes, either of them alone, or in combination with the others, have been generally regarded as responsible for the undeniable decline of seal life on the seal islands of the Bering Sea and North Pacific Ocean, viz, excessive driving of the male seals, raids on the rookeries, and pelagic sealing. It may be well to inquire

how each of these alleged causes applies to the conditions prevailing on the Russian islands.

It has been claimed that the *driving* of the male seals results in sapping their vitality and impairing their procreative powers, thus causing a double decline by shortening the life of the individual and causing a smaller number of pups to be born. I have elsewhere in this report discussed this question. Here it will suffice to simply inquire, How do the facts observed on the Commander Islands agree with this theory? I have already summarized the facts, but they will bear a brief repetition. On Bering Island the driving is so easy that even the black pups driven in flocks with the adults are uninjured; yet there was quite a deficiency in bulls, virile and otherwise. On Copper Island the drives are beyond comparison the hardest known anywhere; yet there was a surplus of exceedingly virile bulls; and still, if we may be allowed a comparison with the Pribylof Islands, we may add that the decrease in killables on Copper Island is of a much later date than the corresponding decrease on the Pribylofs. Now, if the driving had had the slightest influence upon the numbers of the seals, how did it happen that the seals were increasing while it is a fact that the drives have never been easier, but if anything rather harsher? Nothing seems more clear and logical than this proposition, viz, that if the driving is the cause of the decline, we should expect the falling off in bulls to have taken place on Copper Island, and not on Bering Island; but the reverse is just the case. I am, therefore, compelled to absolve the driving of the responsibility for the decrease on the Commander Islands.

The contention that the occasional *raids* practiced on the rookeries by marauding schooners are materially to blame for the decrease has found but slight support, and the experience on the Commander Islands does not substantiate it. I have shown that the Commander Islands seals were increasing in spite of the numerous raids in the early eighties; I have also shown how the little rock of Robben Island has continued to yield killable seals in spite of an unparalleled history of raids. It is safe to say that the annual catch of the raiders of the latter island greatly exceeded that of the legitimate killing on shore, and yet the falling off in the yield is not greater than that of the other islands.

There remains the *pelagic sealing*. Up to 1892 there was no startling decrease of the female seals on the Commander Islands rookeries, while there had been for a couple of years some difficulty in getting the former number of killables. In 1892 the sudden invasion of the whole body of the pelagic sealing fleet upon the unprotected feeding-grounds of the Copper Island female seals took place, followed by similar inroads in 1893 and 1894. The melancholy decimation of the female seals on the Copper Island rookeries as witnessed by me in 1895 can be directly traced to this preying upon the herd off Copper Island. The extension of the hunt to the Bering Island feeding-grounds in 1895 explains easily the presence in great numbers of pups starved to death on the Bering Island Rookery. The somewhat earlier falling off in killables is attributable to the increase in the winter and spring catch off Japan.

The simultaneous or sequential occurrence of the above facts and phenomena is evidently more than a mere coincidence. As cause and result, they fit like a hand in a glove, and *I have been unable to resist the force of the logic which places the blame for the decrease of the Commander Islands seals upon pelagic sealing, and upon pelagic sealing alone.*

FUTURE PROSPECTS ON THE COMMANDER ISLANDS.

The Commander Islands seal herd, originally and at its best only half the numerical strength of the Pribylof herd, is being killed off so rapidly that in a season or two it must become utterly unprofitable to hunt them in the open sea. If the destruction is allowed to go on much further it is feared that it will take a very long time before the rookeries can be to any degree restored, even under the most effective protection.

If, on the other hand, really protective measures could at once be instituted, I am of the opinion that it will be possible to repair the damage within a reasonable time. It may not be possible to bring back the palmy days of 50,000 skins a year, but it might yet be feasible to render the business profitable to the natives, the Government, and the fur trade.

This may to many appear as a rather optimistic view, but I base my opinion on the well-established fact of the quick recovery and rapid replenishing of the rookeries during the beginning of the lease of Hutchinson, Kohl, Philippeus & Co., as well as upon the wonderfully recuperative powers of the herds as demonstrated in the history of Robben Island. A graphic demonstration of an estimated increase would bear out this opinion, but as being chiefly speculatory, and therefore outside the limits which I have endeavored to keep in this report, is here left out of consideration.

RECOMMENDATIONS.

The Commander Islands being outside the boundaries of our own country, recommendations by the present writer as to the protection and management of the fur-seal business may seem to be out of place. Perhaps, therefore, I ought to have called the following paragraphs suggestions rather than recommendations. The friendly cooperation shown by the Russian authorities, however, has led me to give these, my personal opinions, a more definite form.

In the first place, any protection to be effective must be established by international agreement between all the powers directly interested, viz, Russia, Japan, Great Britain, and the United States. Separate action is apt to be disastrous. It has thus far not only resulted in protective regulations which do not protect, but the English-American *modus vivendi* of 1892 was unquestionably the beginning of the ruin of the Commander Islands rookeries.

As to the measures to be recommended, it may at once be stated that only radical and total prohibition can be effective. A short period of complete stoppage of sealing will produce more good than three times as long a period of partial protection. The recent history of fur-seal protection has shown the utter failure of halfway measures.

The special recommendations which I should be inclined to make are as follows:

(1) Total and absolute prohibition of pelagic sealing in the North Pacific Ocean and Bering Sea at all seasons for at least six years.

(2) After that time total prohibition at all seasons in Bering Sea and Pacific Ocean west of 175° east longitude and north of 52° north latitude, or, if preferable, within a zone of 150 nautical miles from the islands.

(3) Total prohibition of killing on land for one year.

(4) After that time bachelor seals to be taken on land not later than August 1.

The total prohibition of pelagic sealing for six years is thought to be sufficient to restock the rookeries with females to the extent that at least an equilibrium of the herd may be attained.

One year's total prohibition on land is thought sufficient to furnish enough males to start with for the increasing number of females. It is also supposed that there will be enough males left every year from those not hauling out until August 1. The reason why I do not advocate a longer prohibition of killing on land than one year is that I regard a large surplus of mature males on the rookeries beyond the actually indispensable number for the impregnation of every female as a check to the increase of the herd. The herds on the Commander Islands, as well as on the Pribylof Islands, must have been practically at equilibrium at the time of their discovery by man, and I attribute this solely to the fact that there must have been a superabundance of males sufficient to prevent an increase. The killing off of the superfluous number of males must inevitably result in a rapid increase of the herd. Similar conditions exist among other polygamous animals, which have been known to increase rapidly by the killing off of a great number of the males.

The natives would have to be supported for one year, but that undertaking ought not to be so expensive on the Commander Islands as it might appear at first glance. The first thing to be done would be to exterminate the sledge-dogs on Bering Island. They eat more seal meat and fish than the natives, and are a general nuisance. A few Kamchatka horses would do much better service than all the dogs, and, supplemented with a few more good boats on the island, would suffice for transportation and travel. The Bering Islanders, having nothing else to do during the whole year of the prohibition, could easily put up an extra quantity of dried salmon at Saranna, which, with the quantity saved from the dogs, would go a long ways toward the feeding of the Copper Islanders. The latter, having still the sea-otters, could well afford to pay the Bering Islanders something for the fish. Besides, it might be so arranged as to have fox hunts on both islands during the year of the "zapuska," or prohibition.

There seems to be no good reason why the Governments in question should not be able to agree upon some such scheme of protection, which appears to be both equitable and effective. However, should both reason and self-interest prove unavailing, and it should be found impossible to effect a satisfactory protection, the question naturally arises, What is to be done with the remaining seals?

There would certainly be no reason for limiting the number of male seals to be taken on land. The restriction placed upon the killing on the islands under the present conditions results in nothing but a one-sided attempt at preservation of the rookeries for the benefit of the pelagic sealers.

As for a total extermination of the herd, simply to prevent the pelagic sealers from getting any more seals, it may well be remarked that the measure seems well-nigh superfluous, as there will soon be no seals for the pelagic sealers to kill. A perusal of the chapter on Robben Island might raise the question whether it would be effective.

However, the issue is not an actual one in the present case; for, so far as I know, the Russian authorities are not publicly discussing the possibilities of such a step. At the same time it should not be forgotten that Russia's position is more advantageous than that of the United States in this respect, as it is bound by no such moral obligations, much less legal ones, as would have confronted her had she ever submitted the main points in the case to international arbitration.

LIST OF ILLUSTRATIONS.

(The maps and photographs are by the author unless otherwise stated.)

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25*a*.—Beach at North Rookery, Bering Island. Group of natives with seal skins at the landing-place waiting for the boats from the steamer. Salt-house in the background to the left.

25*b*.—Village at North Rookery, Bering Island. To the left the company's house; in the center the kossak's house; in the background the yurts, or sod huts, of the natives (the new village). From salt-house, August 13, 1895.

26*a*.—Reef, North Rookery, Bering Island, July 4, 1895, about 2 p. m. Reduced copy of photographs by C. H. Townsend. Breeding seals in three disconnected patches to the left of picture.

26*b*.—Same. July 9, 1895, about 5 p. m. Photograph by N. Grebnitski, showing the breeding seals occupying a continuous area; also the "band" across the "sands."

27*a*.—Reef and Sivutchi Kamen, North Rookery, Bering Island. Photograph by Colonel Voloshinof, 1885. From nearly same point as pl. 22, with which it should be compared for distribution of seals on breeding-ground.

27*b*.—Steller's Arch, near South Rookery, Bering Island, August 17, 1895.

28.—South Rookery, Bering Island, from the west (photographic station No. 3, see map, pl. 10) toward the waterfall. August 17, 1895, 2 p. m.

29.—South Rookery, Bering Island, looking west from photographic station No. 1. August 17, 1895, noon.

30.—South Rookery, Bering Island. Females and pups. From photographic station No. 2. August 17, 1895, noon.

31*a*.—South Rookery, Bering Island. Copy of photograph by Colonel Voloshinof to show distribution of seals in 1885. Western half.

31*b*.—Same. Eastern half. Both from nearly same standpoint as my pl. 29.

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32*b*.—Waterfall at South Rookery, Bering Island.

33.—Preobrazhenskoye village, Copper Island, looking west. In the background, Pestshani Mys, the tops being hidden in the fog, and the company's steamer, *Kotik*, at anchor. The nearest light-painted house is the schoolhouse; the one farther back is the dwelling and office of the assistant administrator; the dark houses to the right of it are the company's store, magazines, and dwelling-house. July 28, 1895.

34*a*.—Karabelni village, Copper Island, from the beach at mouth of river. August 12, 1895.

34*b*.—Glinka village, Copper Island, from the hill behind it. August 7, 1895.

35.—Glinka village, Copper Island, from the beach. In the middle ground the salt-houses to the left, the government's house to the right. August 11, 1895.

36*a*.—Interior of salt-house, Glinka, Copper Island. Seal skins in salt.

36*b*.—Same. Seal skins bundled, ready for shipment.

37.—Beach at Glinka village, Copper Island. Natives getting ready to leave for the main village after having finished the sealing.

38*a*.—Karabelni Stolp, Copper Island, from photographic station No. 4 (see map, pl. 12). August 1, 1895, noon.

38*b*.—Karabelni Stolp, Karabelnoye Rookery, Copper Island. From bluff, photographic station No. 1. August 2, 1895, 9.15 a. m.

39.—Karabelnoye Rookery, Copper Island, looking west toward Karabelni Stolp, from photographic station No. 3. August 1, 1895, 11 a. m.

40.—Karabelnoye Rookery, Copper Island, looking east toward Vodopadski Mys, from photographic station No. 2. August 1, 1895, 10 a. m.

41.—Karabelni Stolp, Copper Island. Pencil sketch by the author, July 3, 1883, from photographic station No. 1, to show distribution of seals as compared with my photograph of 1895, from same standpoint, pl. 38*b*.

42.—Karabelnoye Rookery, Copper Island, looking west. Pencil sketch by the author, July 3, 1883, from photographic station No. 3, to show distribution of breeding seals as compared with my photograph of 1895, from same standpoint, pl. 39.

43.—Karabelnoye Rookery, Copper Island, looking east. Pencil sketch by the author, July 3, 1883, from photographic station No. 2, to show distribution of breeding seals as compared with my photograph of 1895, from same standpoint, pl. 40.

44*a*.—Bolshaya Bukhta, Karabelnoye Rookery, Copper Island. From reef at extreme end of Karabelni Stolp. The snow patch at the beach is the same as the one seen near the lower left-hand corner in pl. 40. From a photograph by Mr. Grebnitski, August 1, 1895, 9.45 a. m.

44*b*.—Drive steps, Stolbovaya Bukhta, Karabelnoye Rookery, Copper Island. August 1, 1895. From photographic station No. 5.

45.—Drive steps and waterfall, Vodopad, Karabelnoye Rookery, Copper Island, August 2, 1895.

46.—Palata, Copper Island, seen from Zapadni, to show character of beach. Photograph by Mr. Grebnitski, August 7, 1895.

47.—Palata beach, Glinka, Copper Island, showing the character of the reef. Photograph by Mr. N. B. Miller, of the U. S. Fish Commission S. S. *Albatross*, June 4, 1892.

48.—Palata Rookery, Copper Island, from a rock off the rookery. Looking up the gully to the right, Palata; mountains in the background hidden in the fog. August 2, 1895, 2.30 p. m.

49.—Palata Rookery, Copper Island, from the same point as pl. 48, looking toward Sabatcha Dira. Top of mountains hidden in the fog. August 2, 1895, 2.30 p. m.

Plate No.

50.—Palata Rookery, Copper Island, from nearly the same point as pl. 55, looking down the gully toward Karabelni. In lower left-hand corner, slope of Palata; in upper right-hand corner, Zapadni and Pestshani Mys. August 7, 1895, 12.30 p. m.

51.—Palata Rookery, Glinka, Copper Island, August 7, 1895, 9.40 a. m. From hill north of Palata, on map (pl. 14) marked 806 feet.

52.—Palata Rookery, Glinka, Copper Island. From a sketch by the author, July 16, 1883. Standpoint same as my photograph of 1895 (pl. 51) to show distribution of seals.

53*a*.—Palata Rookery, Glinka, Copper Island. Photograph by Colonel Voloshinof, 1885. Standpoint a little farther to the right and lower down than my sketch of 1883 (pl. 52) and my photograph of 1895 (pl. 51).

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54*a*.—Zapadni Rookery, Glinka, Copper Island. From same point as pl. 51 (hill on map 14 marked 806 feet) looking west. The extreme promontory in the background to the left is Vodopadski Mys, then follow Lebiazhi Mys and Pestshani Mys. August 7, 1895.

54*b*.—Urili Kamen Rookery, Glinka, Copper Island. Looking from Peresheyek toward Pestshani Mys, which is hidden in the fog. Breeding seals among the stones in the foreground. August 3, 1895, 10 a. m.

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58*a*.—Driveway from Zapadni Rookery, Glinka, Copper Island. Rainy morning. August 8, 1895, 7.30 a. m.

58*b*.—Driveway up from Pestshani hauling-grounds, Glinka, Copper Island. August 2, 1895.

58*c*.—Pestshani salt-house, near Glinka village, Copper Island. August 4, 1895.

59*a*.—Hutchinson, Kohl, Philippeus & Co.'s steamer *Aleksander II*. From a photograph by H. W. Domes, Oakland, Cal.

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60.—Salmon weir, "Zaporr," across the river at Saranna, Bering Island. July 20, 1895. The weir is full of silver salmon.

61*a*.—Saranna village, west half, Bering Island. The salmon weir in the foreground. July 20, 1895.

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62*a*.—Native dragging along a seal which is too tired to move. Drive from Zapadni, Glinka, Copper Island. August 8, 1895, 8.45 a. m. Drizzling rain.

62*b*.—Baby skin-carrier. Same drive.

63*a*.—Salt-house at Popofski, near Karabelni village, Copper Island. August 12, 1895.

63*b*.—Seals sliding down the last embankment, Glinka village, Copper Island. Drive, August 8, 1895.

64.—Dead seal pups in wind rows, Reef, North Rookery, Bering Island. September 16, 1895, 8.15 a. m.

65*a*.—Petropaulski harbor, Kamchatka, from hill behind the town. In the background, on the south side of Avatcha Bay, the volcano Velutchinskaya Sopka. The men-of-war, the British cruiser *Porpoise* (white) and the Russian transport *Yakut* (black), off the Russian Seal Skin Company's wharf. August 26, 1895.

65*b*.—Petropaulski, Kamchatka, from the Russian Seal Skin Company's wharf. In the background the volcano Koriatskaya Sopka. The vessel anchored in the stream is the Russian transport *Yakut*. September 2, 1895.

66*a*.—The Russian Seal Skin Company's wharf, magazines, and steamer *Kotik*, Capt. C. E. Lindquist, at Petropaulski, Kamchatka. September 4, 1895.

66*b*.—Headquarters of the Russian Seal Skin Company, Petropaulski, Kamchatka. September 2, 1895.

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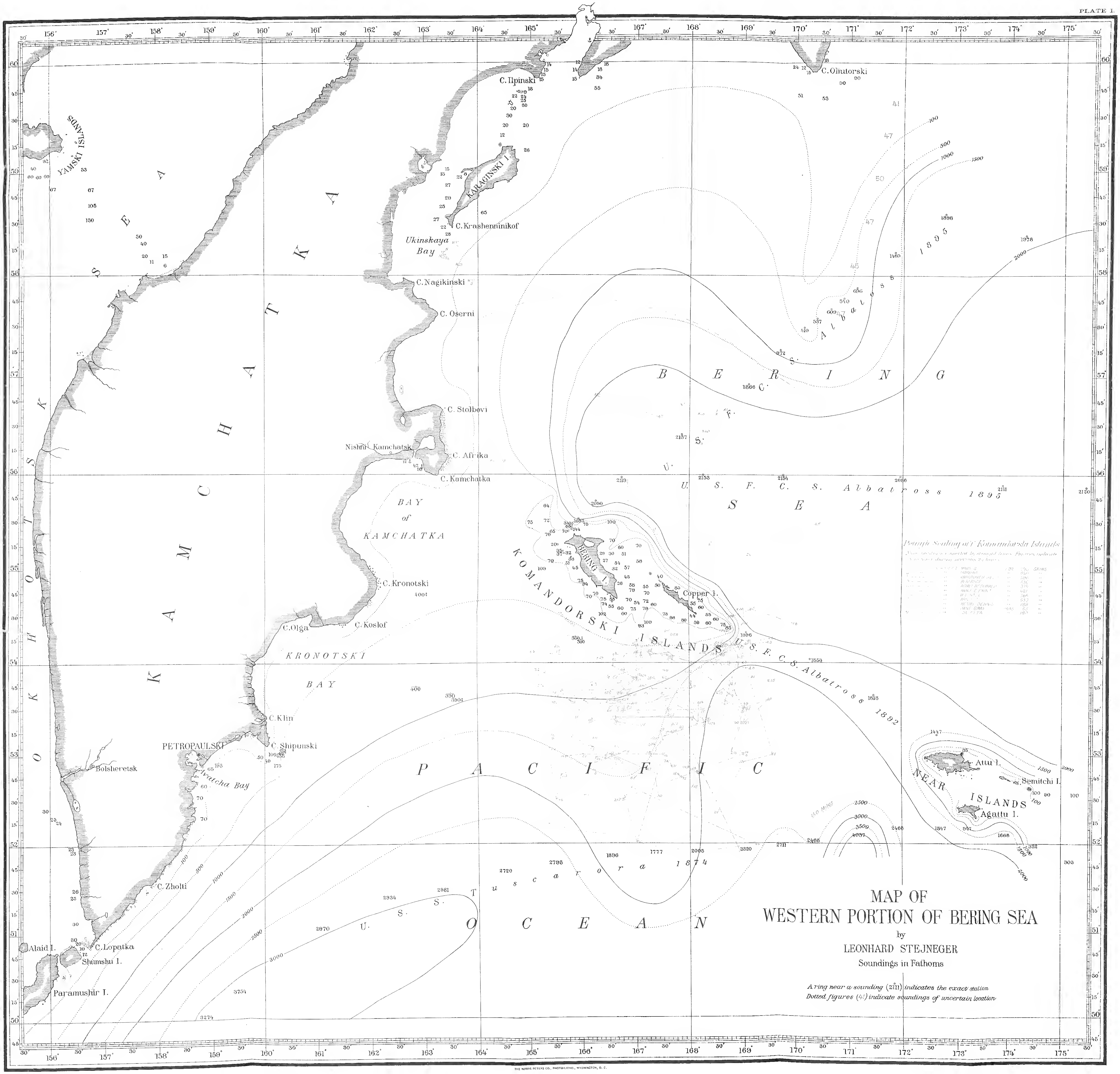

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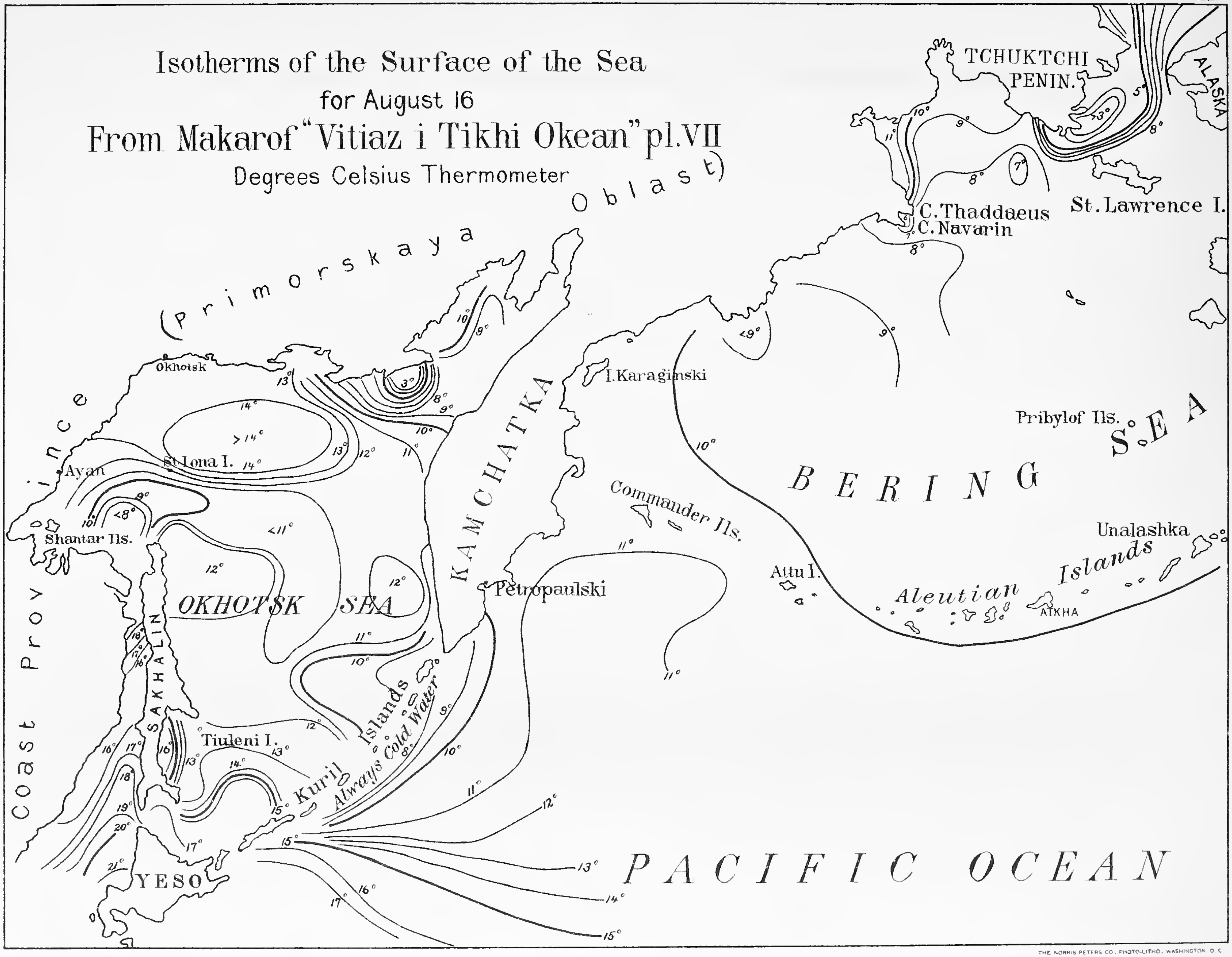

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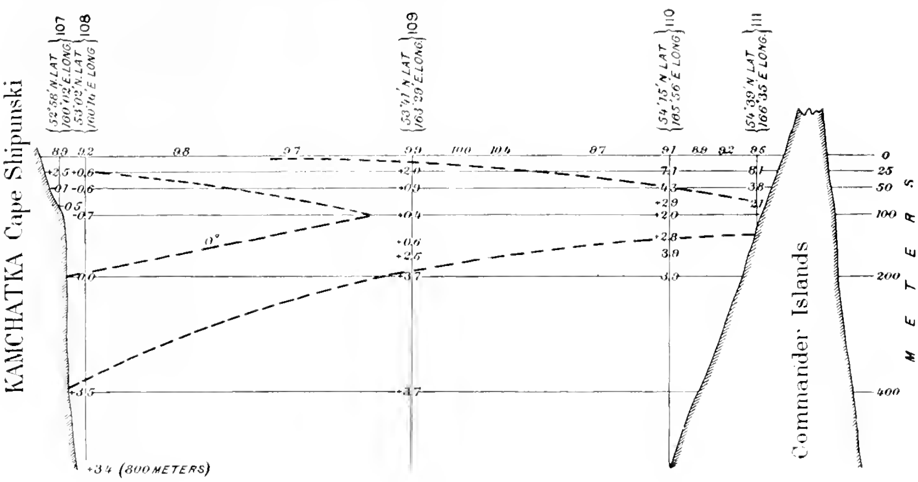
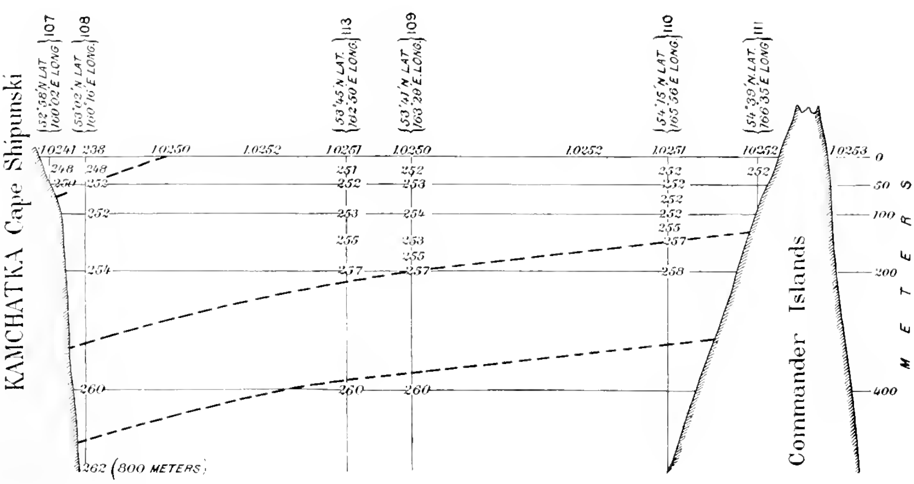
TEMPERATURES



SPECIFIC GRAVITY

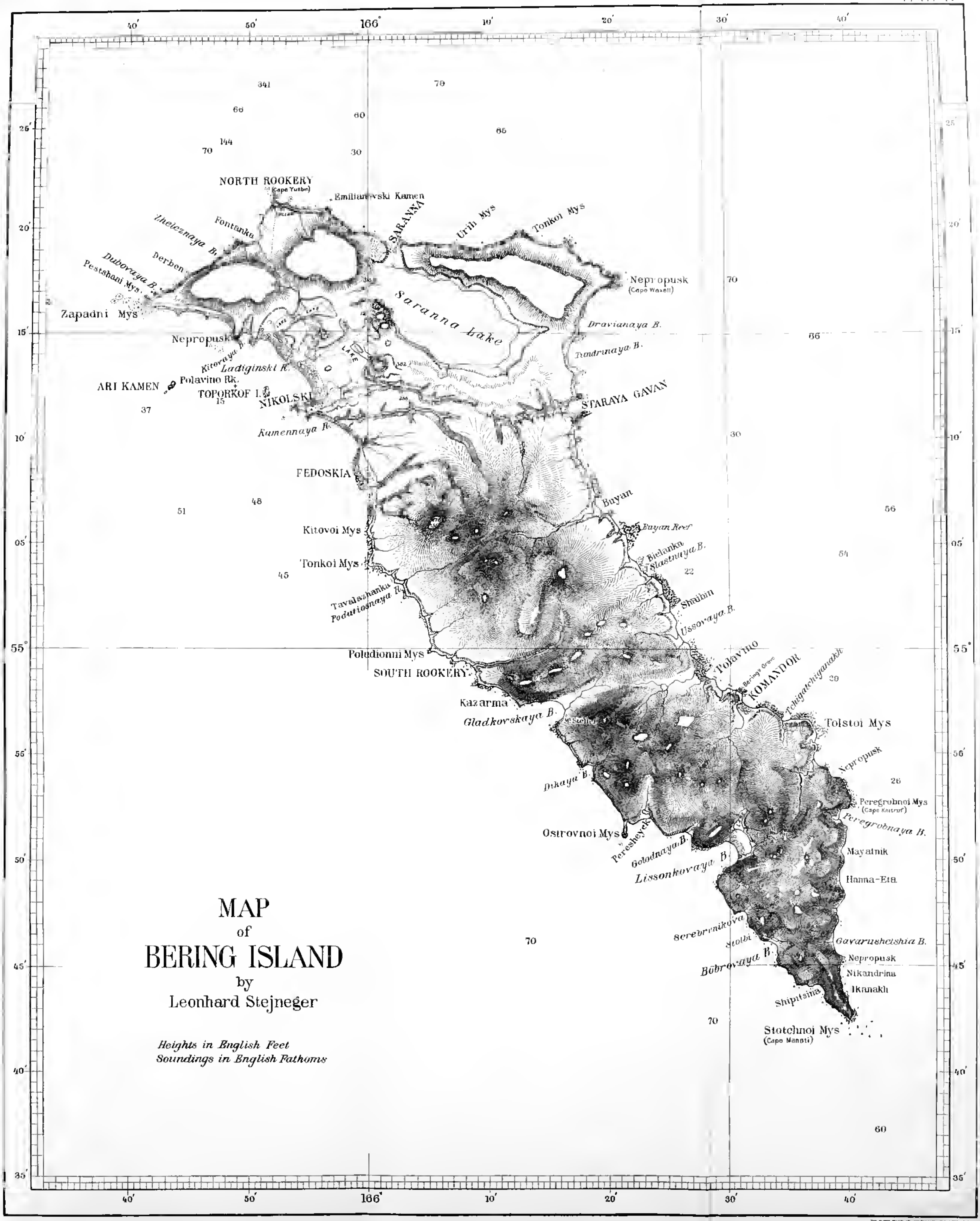


TEMPERATURES AND SPECIFIC GRAVITY OF THE WATER IN BERING SEA BETWEEN KAMCHATKA AND THE COMMANDER ISLANDS, JULY 29 TO AUGUST 2, 1888.

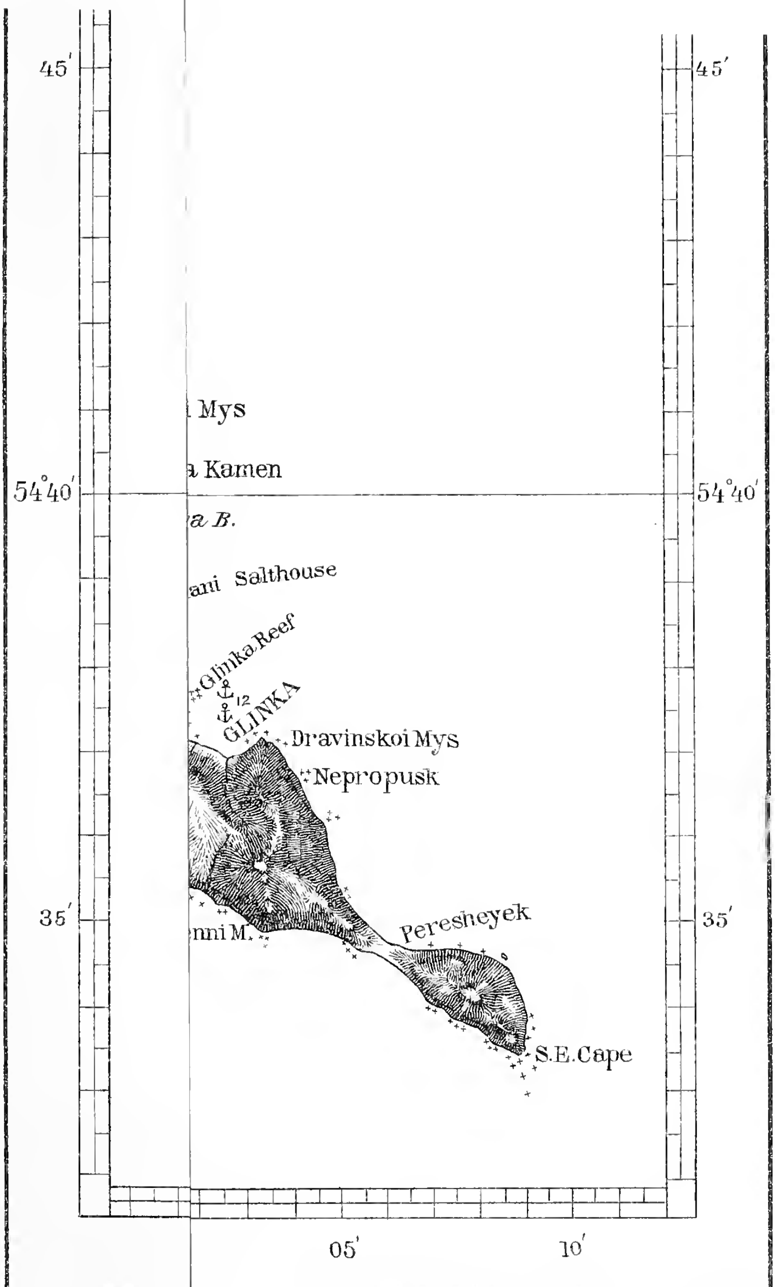
(From Makarof's "Vitiaz i Tikhi Okean," Pl. VIII, by permission of the author.)

"Vitiaz" Station No. **107**, July 29, 4 p. m.; **108**, July 29, 6.40 p. m.; **109**, July 30, 9 a. m.; **110**, July 30, 8.15 p. m.; **111**, July 31, 8.37 p. m.; **113**, August 2, 4.30 p. m.

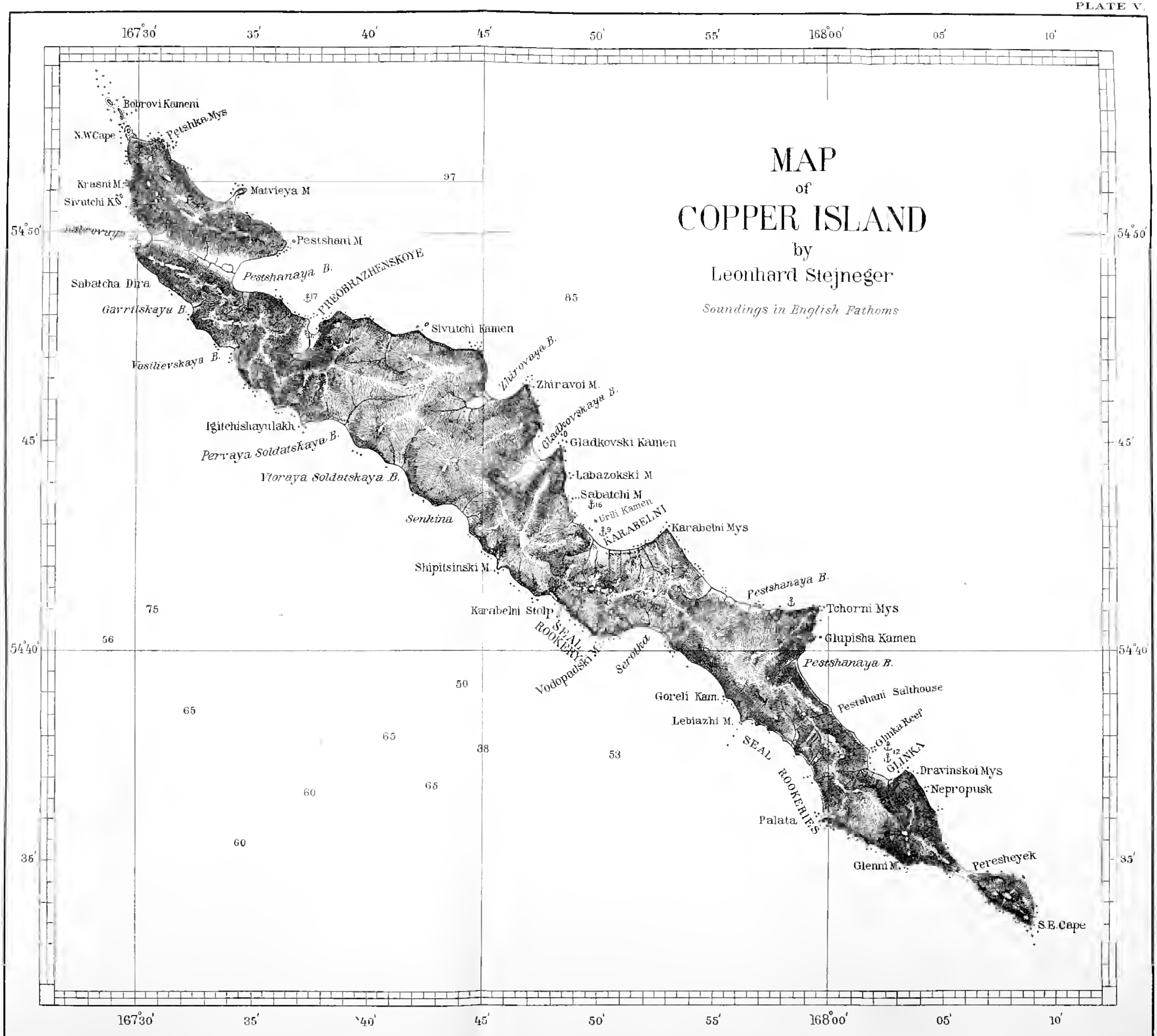
Temperatures in centigrades; depths in meters.


MAP
of
BERING ISLAND
by
Leonhard Stejneger
Heights in English Feet
Soundings in English Fathoms
NORTH ROOKERY
(Cape Yushin)
Emilianovski Kamen
SARANNA
Urili Mys
Tonkoi Mys
Zheleznaya B.
Fontanka
Berben
Dubovaya B.
Pestshani Mys.
Zapadni Mys
Nepropusk
Saranna Lake
Nepropusk
(Cape Waxell)
Dravianaya B.
Tundrinaya B.
Kitovaya R.
Ladiginski R.
ARI KAMEN
Polavino Rk.
TOPORKOF I.
NIKOLSKI
STARAYA GAVAN
Kamennaya R.
FEDOSKIA
Buyan
Bayan Reef
Kitovoi Mys
Tonkoi Mys
Bielanka
Slastnaya B.
Tavalazhanka
Podutiosnaya R.
Shaibin
Ussovaya B.
Poludionni Mys
SOUTH ROOKERY
Polavino
Bering's Grave
KOMANDOR
Kazarma
Gladkovskaya B.
Tolstoi Mys
Nepropusk
Dikaya B.
Peregrubnoi Mys
(Cape Khitrof)
Peregrubnaya B.
Ostrovnoi Mys
Pereshyck
Golodnaya B.
Lissonkovaya B.
Mayatnik
Hanna-Eta
Serebrenikova
Stolbi
Gavarushelshia B.
Bobrovaya B.
Nepropusk
Nikandrina
Ikrinakh
Shipitsina
Stotchnoi Mys
(Cape Manati)
166°
40'
50'
10'
20'
30'
55°

5



THE NORRIS PETERS CO., PHOTO-LITHO. WASHINGTON, D. C.



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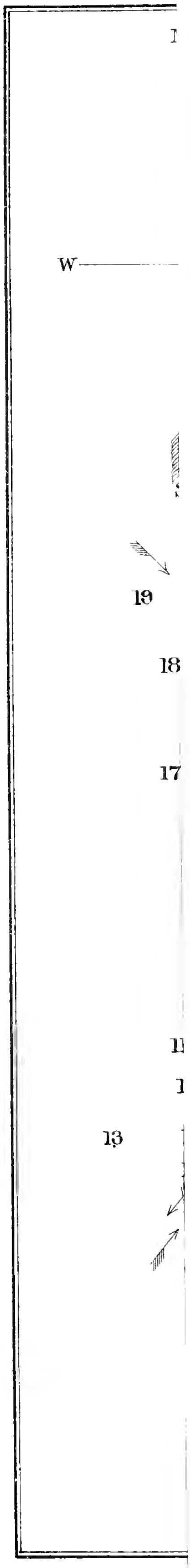
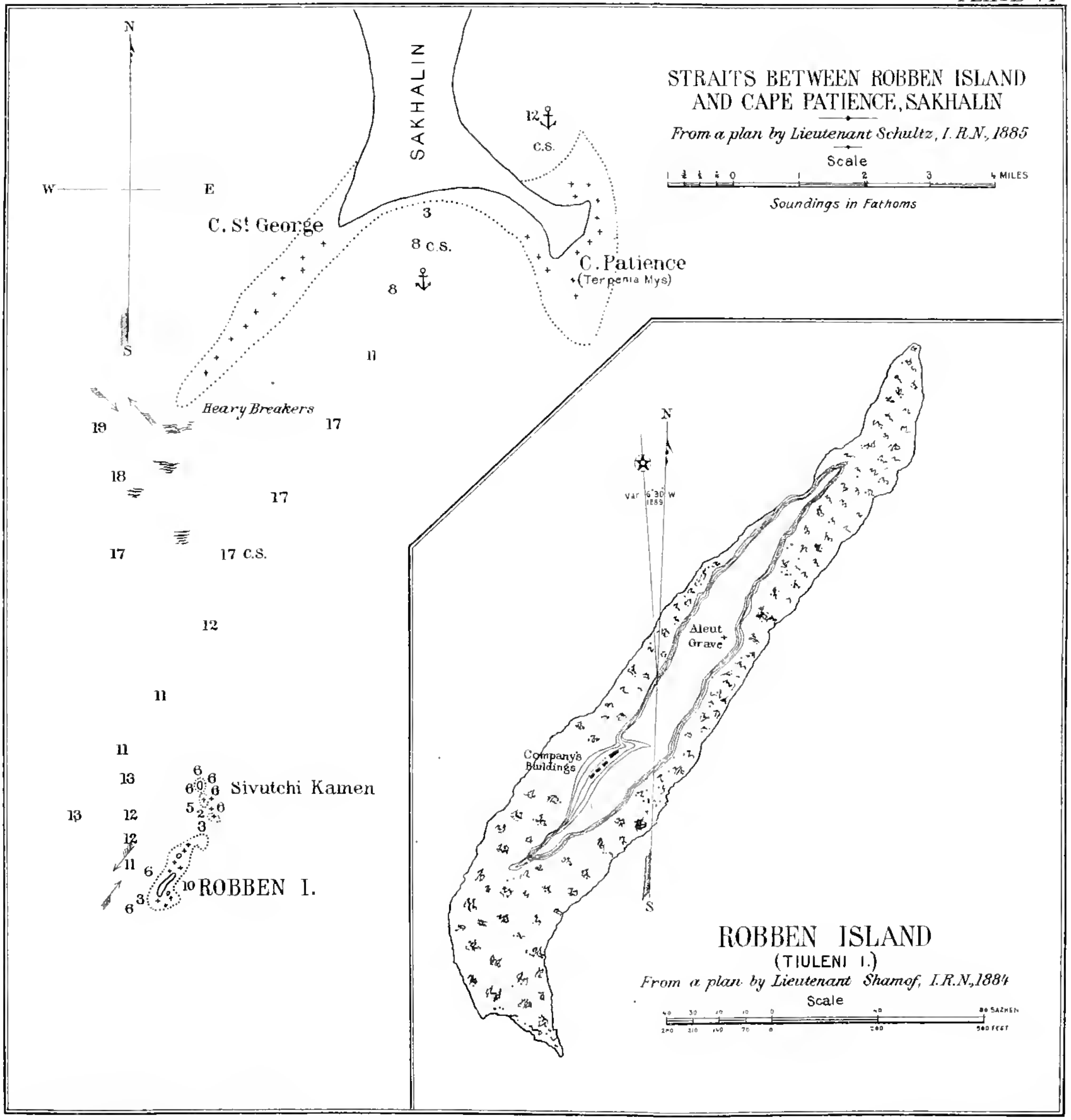
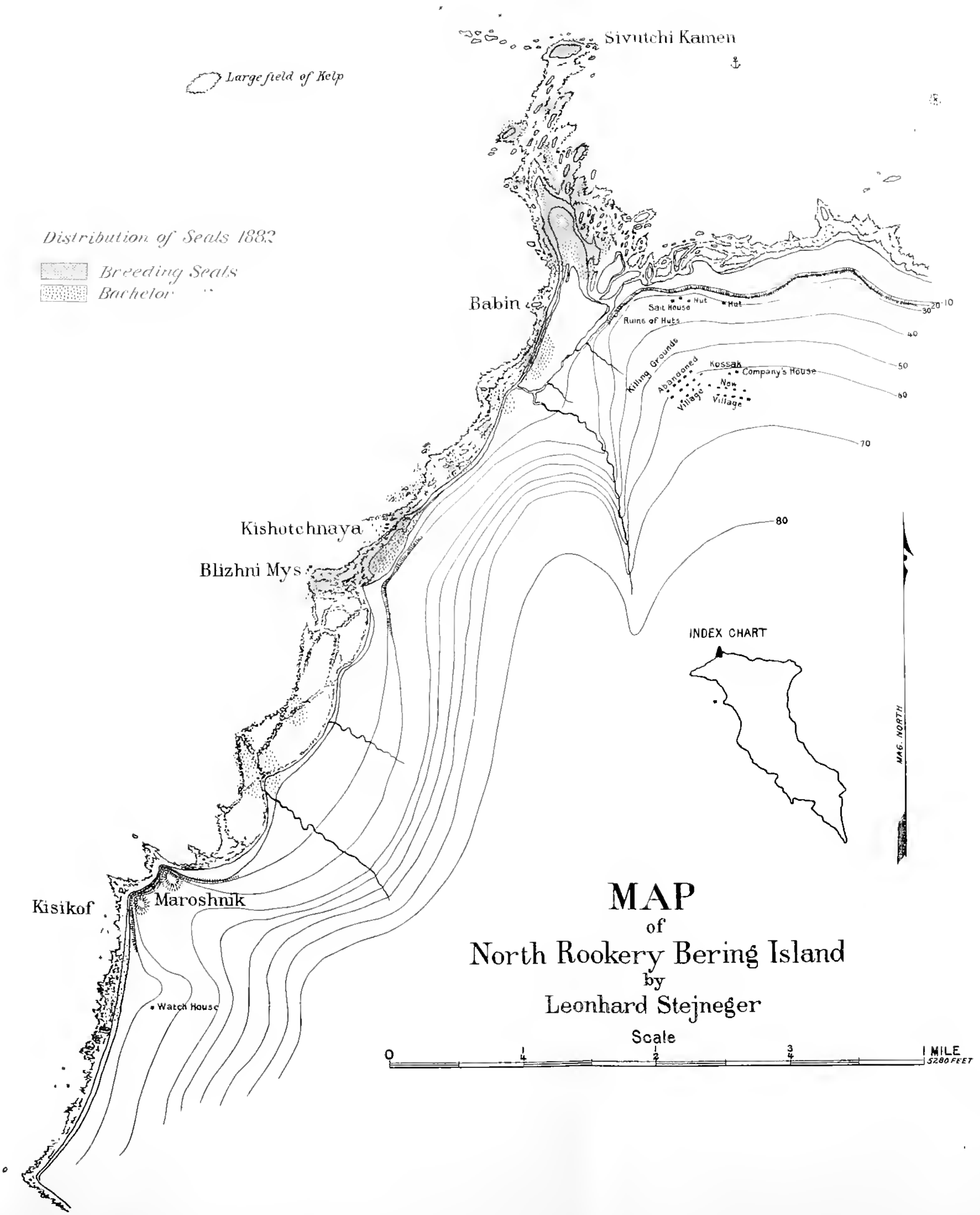
6





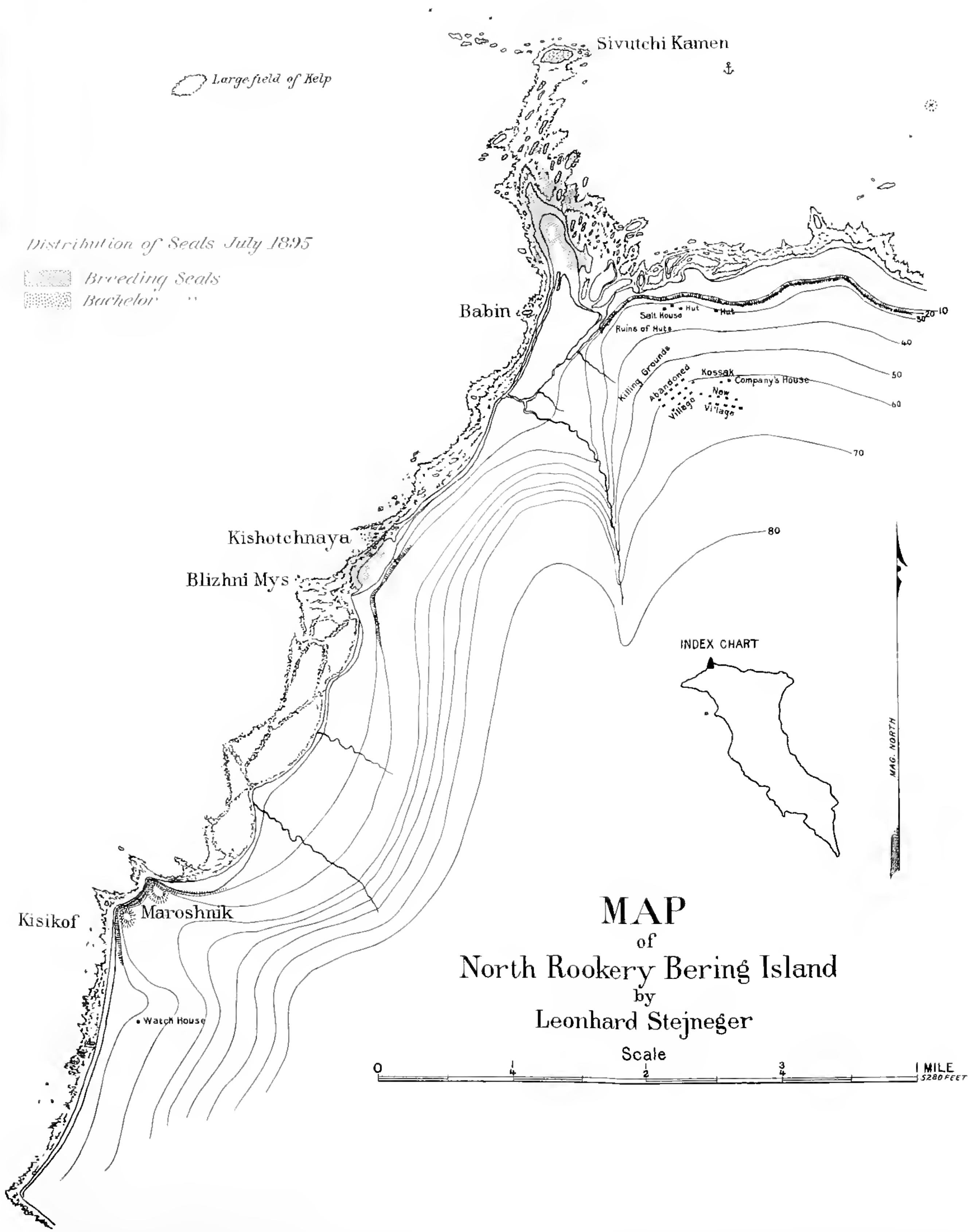
THE NORRIS PETERS CO. PHOTO-LITHO. WASHINGTON, D.C.

Kisik

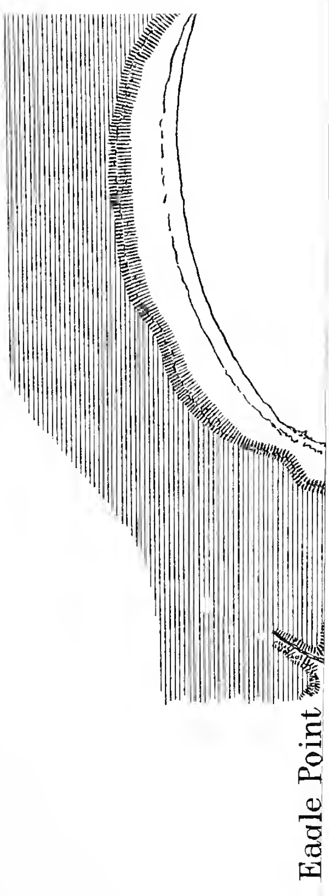


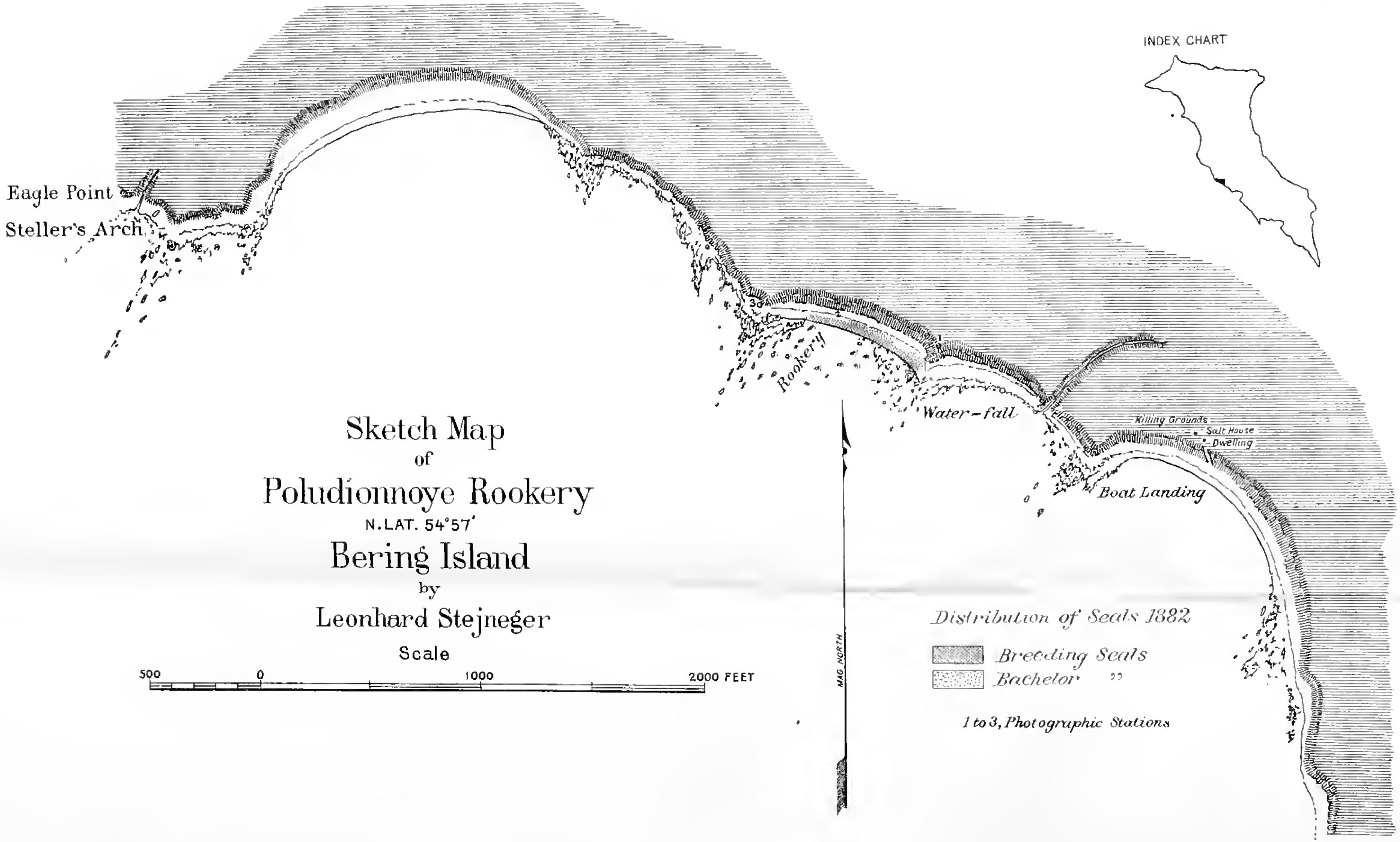
Sivutchi Kamen
Large field of Kelp
Distribution of Seals 1882
Breeding Seals
Bachelor "
Babin
Salt House
Hut
Hut
Ruins of Huts
Killing Grounds
Abandoned Village
Kossak
Company's House
New Village
10
20
30
40
50
60
70
80
Kishotchnaya
Blizhni Mys
INDEX CHART
MAG. NORTH
Kisikof
Maroshnik
Watch House
MAP
of
North Rookery Bering Island
by
Leonhard Stejneger
Scale
0
1/4
1/2
3/4
1 MILE
5280 FEET

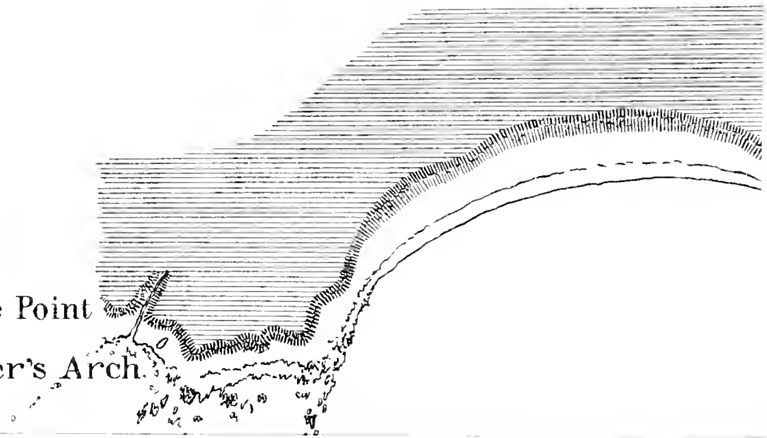

Kisikof

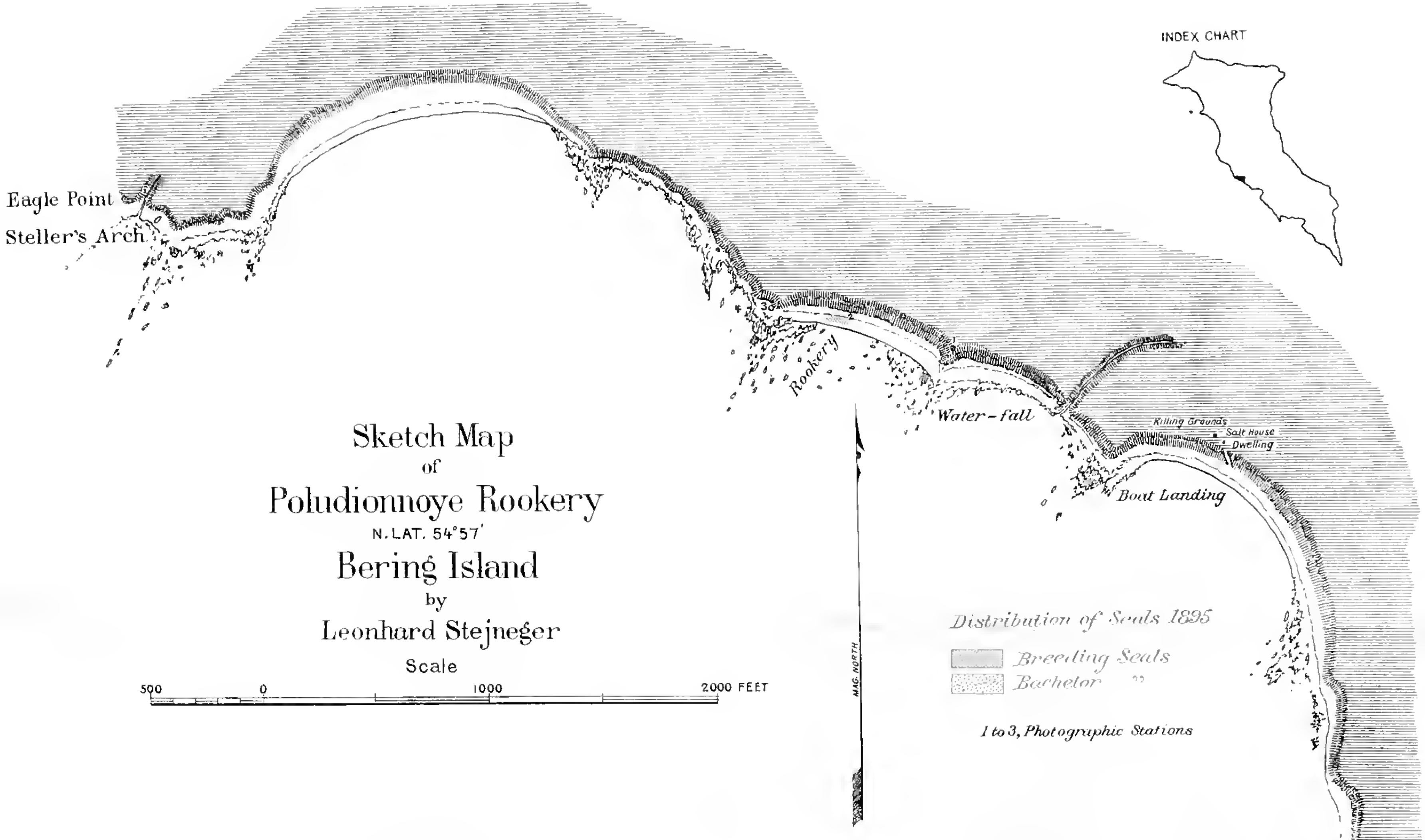

Sivutchi Kamen
Large field of Kelp
Distribution of Seals July 1895
Breeding Seals
Bachelor "
Babin
Salt House
Hut
Hut
Ruins of Huts
Killing Grounds
Abandoned Village
Kossak
Company's House
New Village
10
20
30
40
50
60
70
80
Kishotchnaya
Blizhni Mys
INDEX CHART
MAG. NORTH
Kisikof
Maroshnik
Watch House
MAP
of
North Rookery Bering Island
by
Leonhard Stejneger
Scale
0
1/4
1/2
3/4
1 MILE
5280 FEET

9



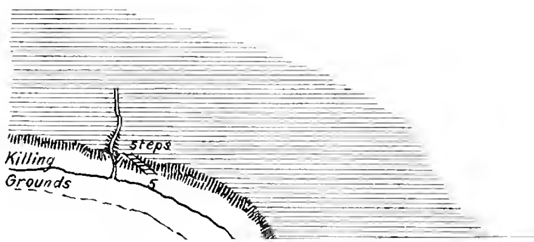

INDEX CHART
Eagle Point
Steller's Arch
3
Rookery
Water-fall
Killing Grounds
Salt House
Dwelling
Boat Landing
Sketch Map
of
Poludionnoye Rookery
N. LAT. 54°57'
Bering Island
by
Leonhard Stejneger
Scale
500
0
1000
2000 FEET
MAG. NORTH
Distribution of Seals 1882
Breeding Seals
Bachelor "
1 to 3, Photographic Stations


Eagle Point
Steller's Arch

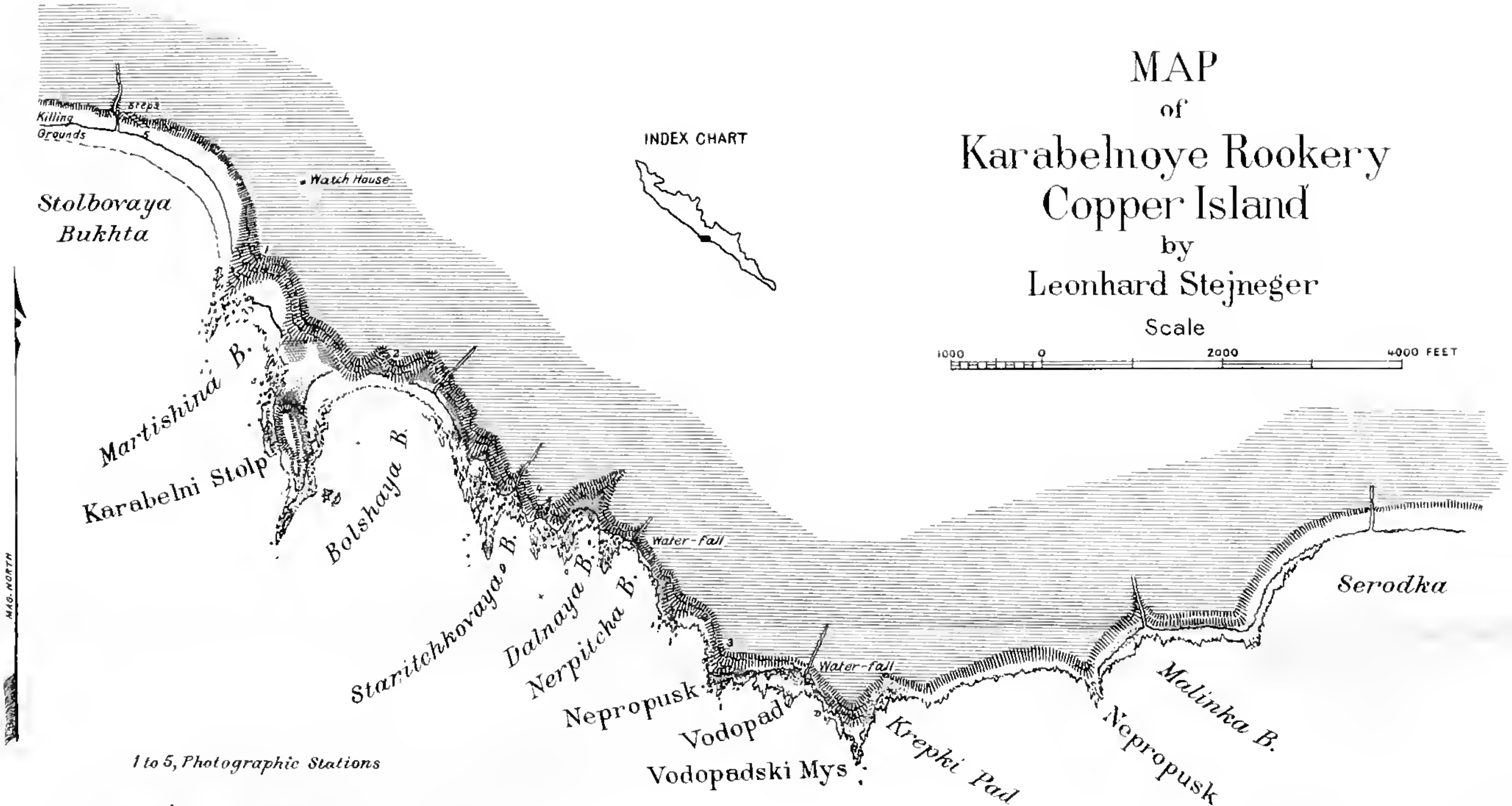


INDEX CHART
Eagle Point
Steller's Arch
Rookery
Water-fall
Killing Grounds
Salt House
Dwelling
Boat Landing
Sketch Map
of
Poludionnoye Rookery
N. LAT. 54°57'
Bering Island
by
Leonhard Stejneger
Scale
500
0
1000
2000 FEET
MAG. NORTH
Distribution of Seals 1895
Breeding Seals
Bachelor "
1 to 3, Photographic Stations

INDEX CHART



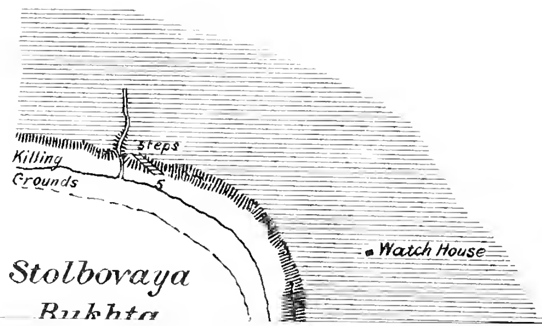
MAP
of
Karabelnoye Rookery Copper Island
by
Leonhard Stejneger



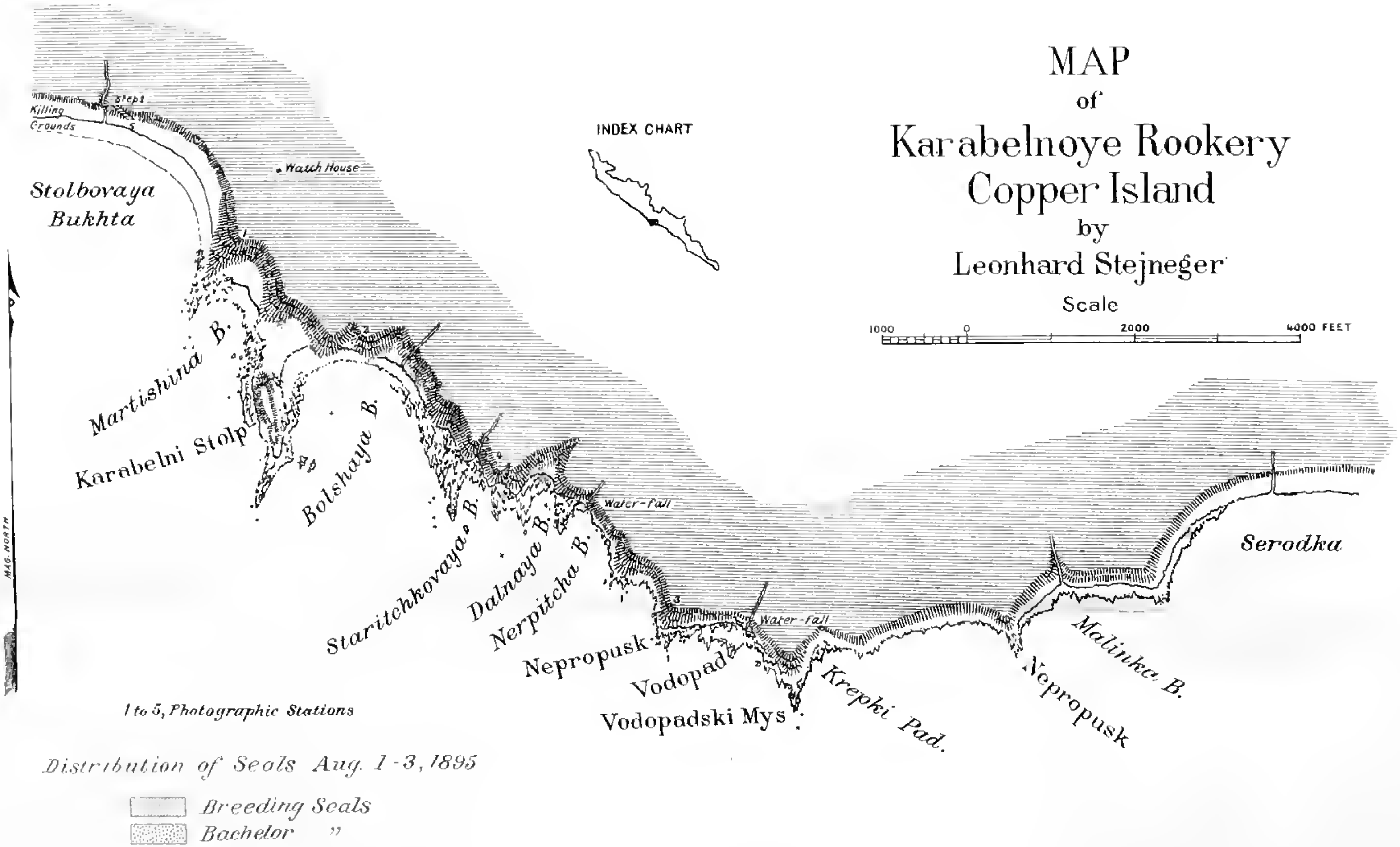
1 to 5, Photographic Stations

Distribution of Seals July 3 10, 1883

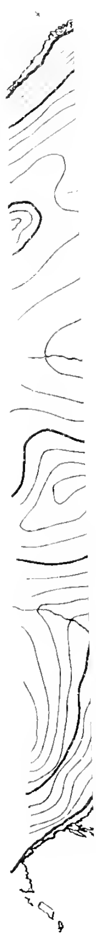
Breeding Seals
Bachelor "

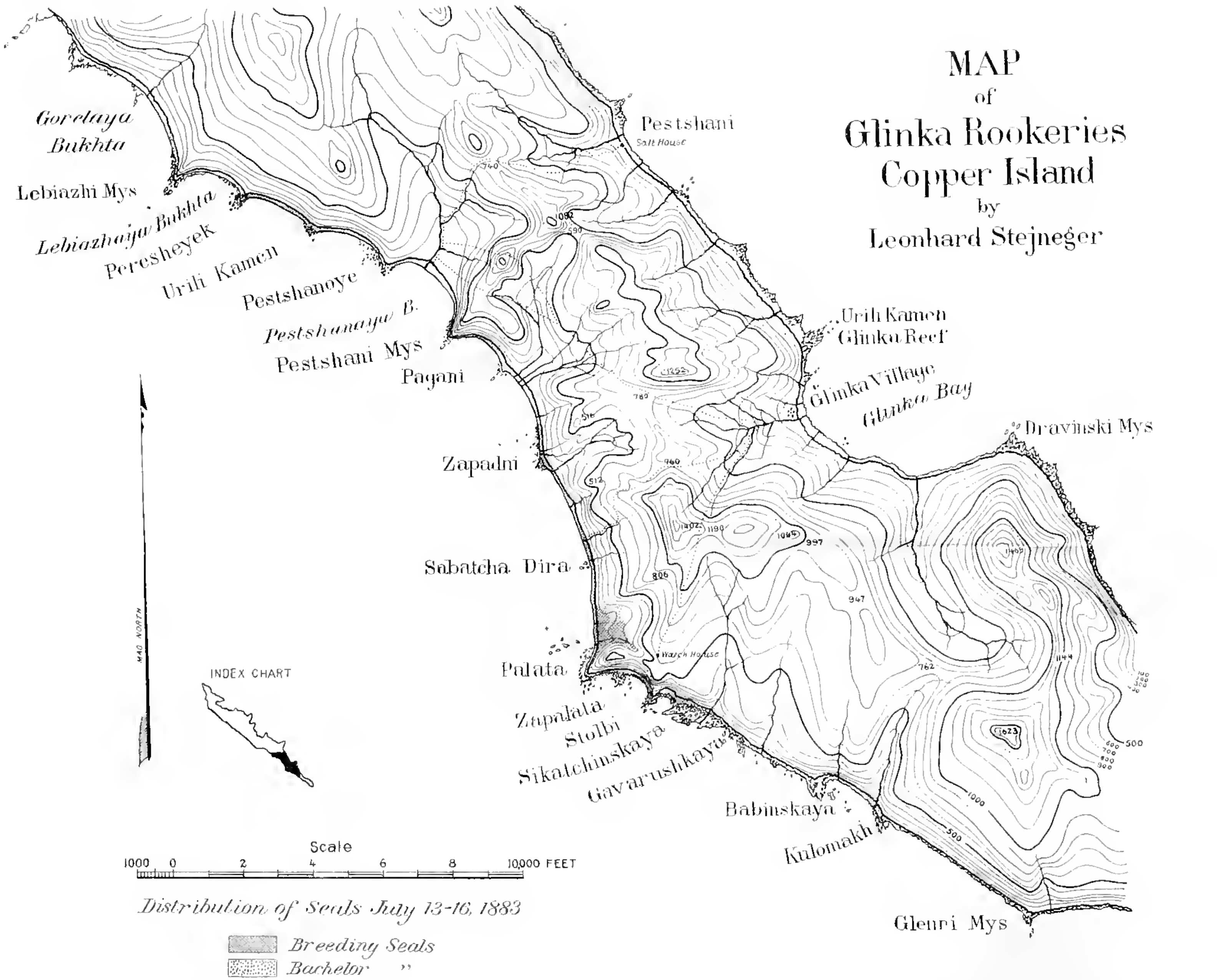


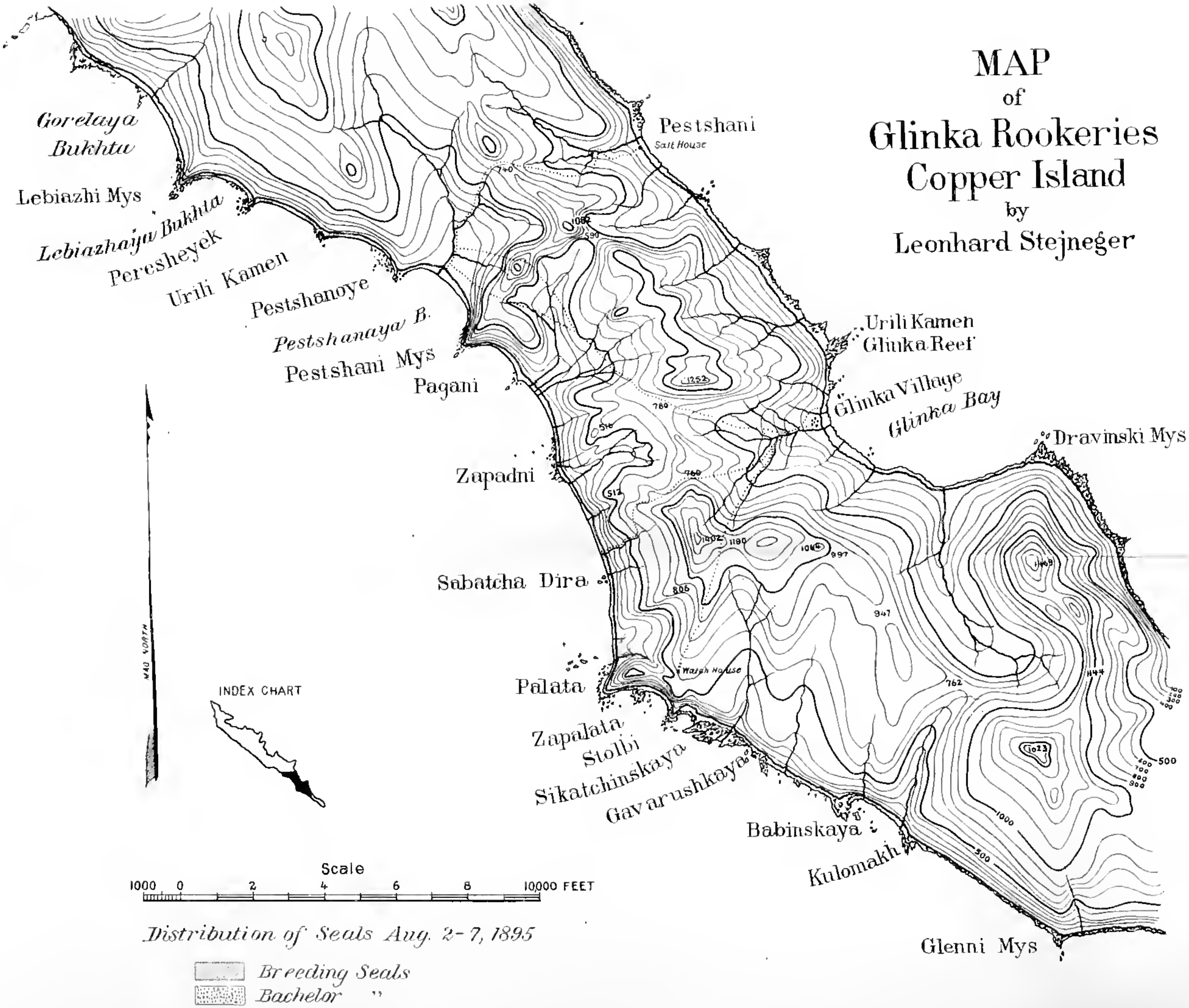
INDEX CHART



THE NORRIS PETERS CO. PHOTO-LITHO., WASHINGTON, D.C.




MAP
of
Glinka Rookeries
Copper Island
by
Leonhard Stejneger
Gorelaya Bukhta
Lebiazhi Mys
Lebiazhaya Bukhta
Peresheyek
Urili Kamen
Pestshanoye
Pestshanaya B.
Pestshani Mys
Pagani
Zapadni
Sabatcha Dira
Palata
Zapalata
Stolbi
Sikatchinskaya
Gavarushkaya
Babinskaya
Kulomakh
Glenri Mys
Pestshani
Salt House
Urili Kamen
Glinka Reef
Glinka Village
Glinka Bay
Dravinski Mys
Watch House
MAG NORTH
INDEX CHART
Scale
1000 0 2 4 6 8 10,000 FEET
Distribution of Seals July 13-16, 1883
Breeding Seals
Bachelor "



THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

a.—Heracleum lanatum, NORTH ROOKERY, BERING ISLAND.

b.—YURT, OR SOD HUT, NIKOLSKI, BERING ISLAND.

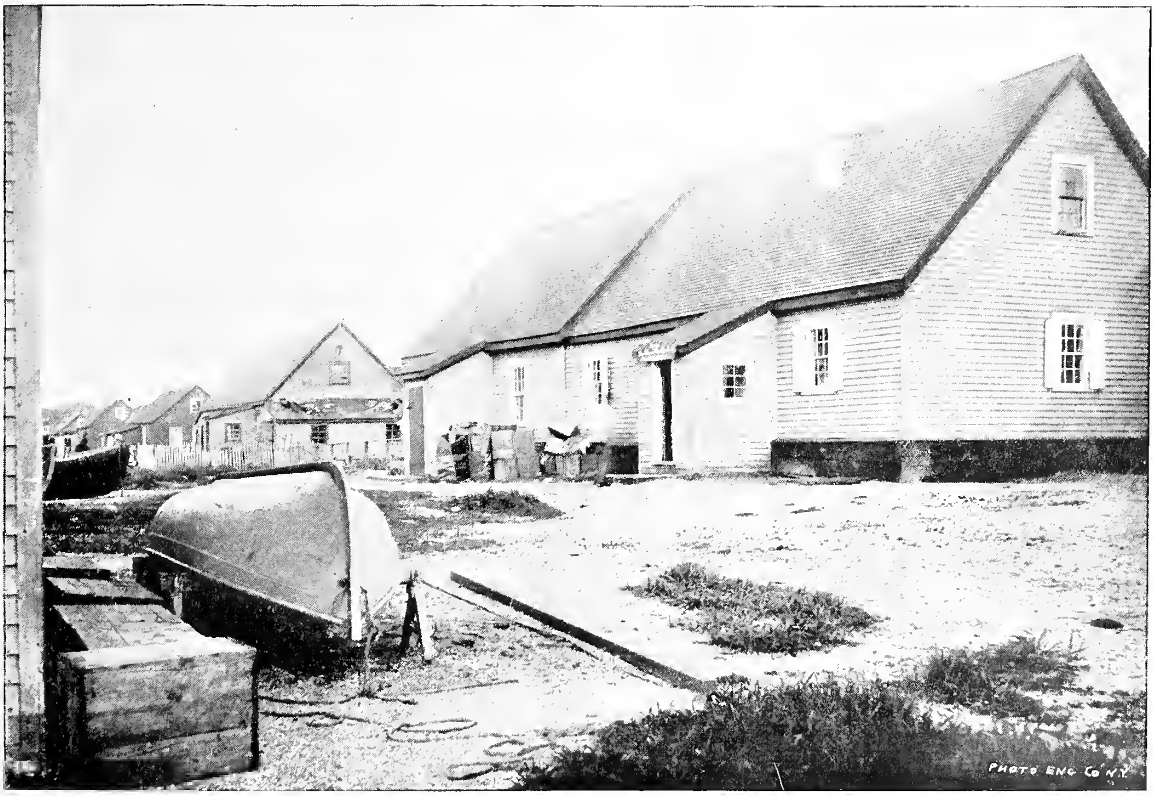
a.—WOODEN FRAME OF YURT, NORTH ROOKERY VILLAGE, BERING ISLAND.

b.—KAMCHATKAN CATTLE, BERING ISLAND.

a.—NIKOLSKI VILLAGE, BERING ISLAND.

b.—NEW SCHOOLHOUSE AND GOVERNOR'S OFFICE, NIKOLSKI, BERING ISLAND.

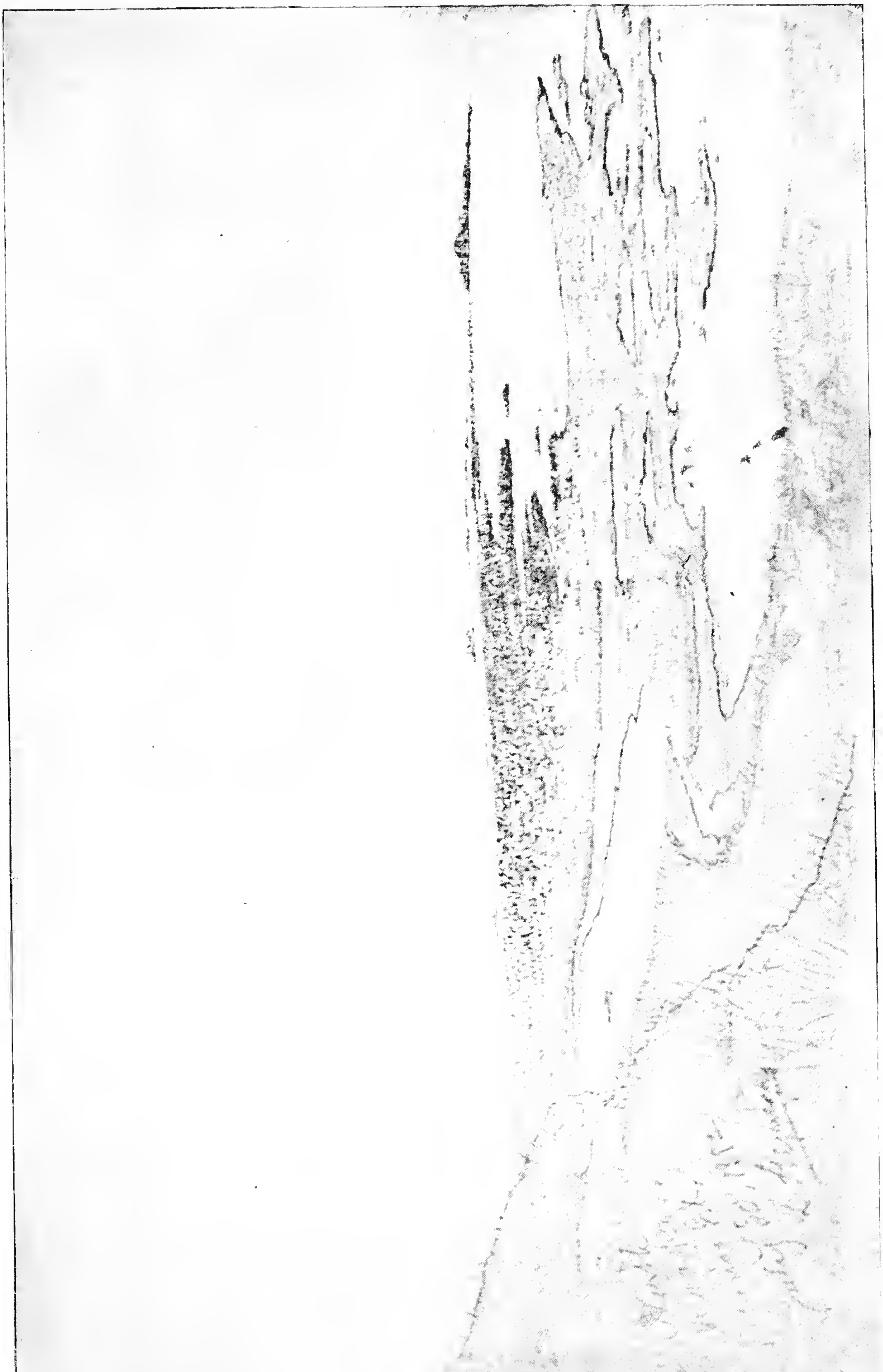
a.—COMPANY'S HOUSE, NIKOLSKI, BERING ISLAND.



b.—COMPANY'S STORE, NIKOLSKI, BERING ISLAND.

a.—REEF AND SIVUTCHI KAMEN, NORTH ROOKERY, BERING ISLAND, FROM SLEDGE ROAD.

b.—SAME FROM DRIVEWAY AT LOWER END OF KILLING-GROUNDS



REEF AND SIVUTCHI KAMEN, NORTH ROOKERY, BERING ISLAND.

Pencil sketch by the author, July 30, 1882, to show distribution of seals.

a.—Western half.

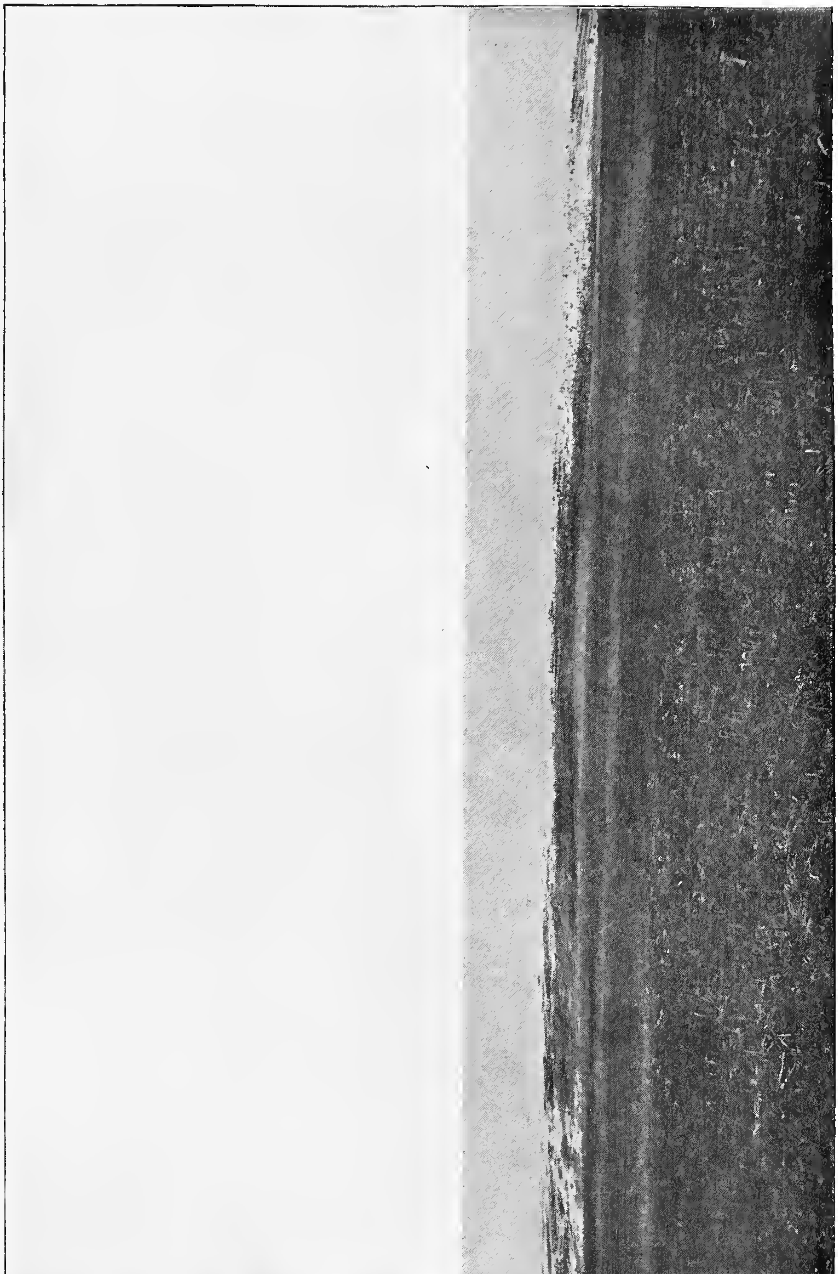
b.—Eastern half.

REEF AND SIVUTCHI KAMEN, NORTH ROOKERY, BERING ISLAND, JULY 15, 1895, TO SHOW DISTRIBUTION OF SEALS.

a.—Western half.

b.—Eastern half.

REEF AND SIVUTCHI KAMEN, NORTH ROOKERY, BERING ISLAND, JULY 15, 1895, FROM DRIVEWAY.



KISHOTCHNAYA, NORTH ROOKERY, BERING ISLAND, JULY 16, 1895.

SALT-HOUSE, WITH SKIN CHUTE, NORTH ROOKERY, BERING ISLAND.

a.—BEACH, NORTH ROOKERY, BERING ISLAND. NATIVES READY TO LOAD SKINS INTO THE BOATS.

b.—VILLAGE AT NORTH ROOKERY, BERING ISLAND. FROM SALT-HOUSE.

a.—REEF, NORTH ROOKERY, BERING ISLAND, JULY 4, 1895. BREEDING SEALS IN THREE DISCONNECTED PATCHES TO THE LEFT.
Reduced from photographs by C. H. Townsend.

b.—SAME, JULY 9, 1895, SHOWING THE BREEDING SEALS OCCUPYING A CONTINUOUS AREA; ALSO THE "BAND" ACROSS THE "SANDS."
Photograph by N. Grebnitski.

a.—REEF AND SIVUTCHI KAMEN, NORTH ROOKERY, BERING ISLAND.

Photograph by Colonel Voloshinof, 1885. From nearly same standpoint as plate 22.

b.—STELLER'S ARCH, NEAR SOUTH ROOKERY, BERING ISLAND.

SOUTH ROOKERY, BERING ISLAND, FROM PHOTOGRAPHIC STATION No. 3 (MAP, PLATE 10). AUGUST 17, 1895.

SOUTH ROOKERY, BERING ISLAND, LOOKING WEST FROM PHOTOGRAPHIC STATION No. 1 (MAP, PLATE 10). AUGUST 17, 1895.

SOUTH ROOKERY, BERING ISLAND. FEMALES AND PUPS. AUGUST 17, 1895.

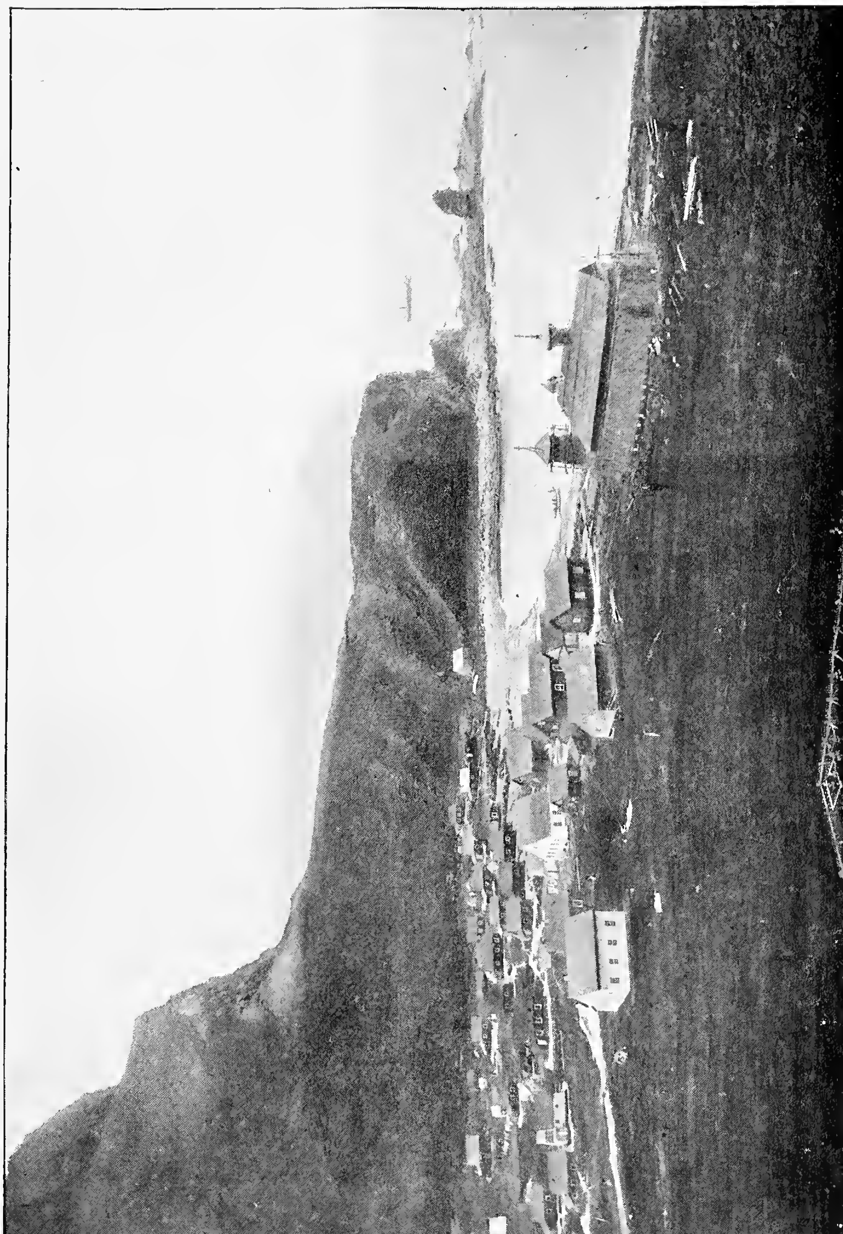
a.—Western half.

b.—Eastern half.

SOUTH ROOKERY, BERING ISLAND. REDUCED COPIES OF PHOTOGRAPHS BY COLONEL VOLOSHINOF, TO SHOW DISTRIBUTION OF SEALS IN 1885. NEARLY SAME STANDPOINT AS PLATE 29.

a.—SALT-HOUSE, SOUTH ROOKERY, BERING ISLAND.

b.—WATERFALL AT SOUTH ROOKERY, BERING ISLAND.

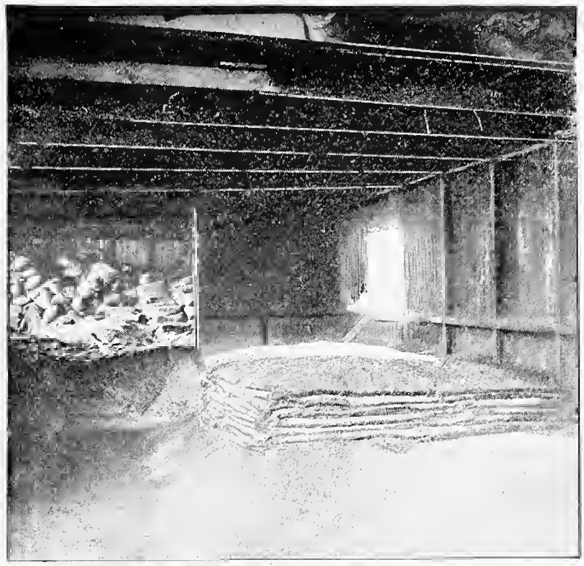


PREOBRAZHENSKOYE VILLAGE, COPPER ISLAND.

a.—KARABELNI VILLAGE, COPPER ISLAND.

b.—GLINKA VILLAGE, COPPER ISLAND, FROM HILL.

GLINKA VILLAGE, COPPER ISLAND, FROM THE BEACH.



a.—Seal skins in salt.

b.—Seal skins bundled, ready for shipment.

INTERIOR OF SALT-HOUSE, GLINKA, COPPER ISLAND.

GLINKA, COPPER ISLAND. NATIVES RETURNING TO THE MAIN VILLAGE.

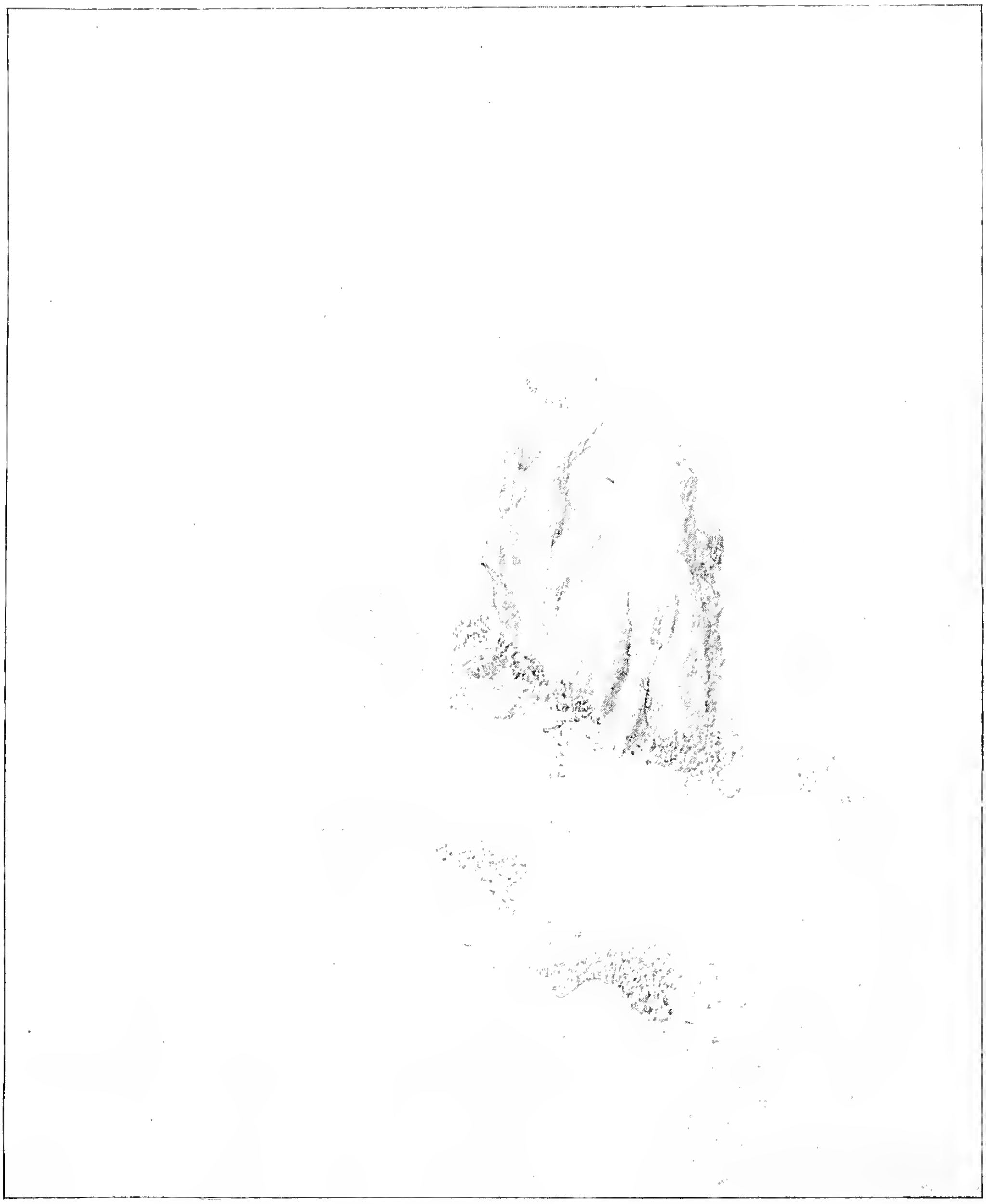
a.—From Photographic Station No. 4 (Map, plate 12). August 1, 1895.

b.—From Photographic Station No. 1, August 2, 1895.

KARABELNI STOLP, KARABELNOYE ROOKERY, COPPER ISLAND.

KARABELNOYE ROOKERY, COPPER ISLAND, LOOKING WEST TOWARD KARABELNI STOLP, FROM PHOTOGRAPHIC STATION No. 3 (MAP, PLATE 12). AUGUST 1, 1895.

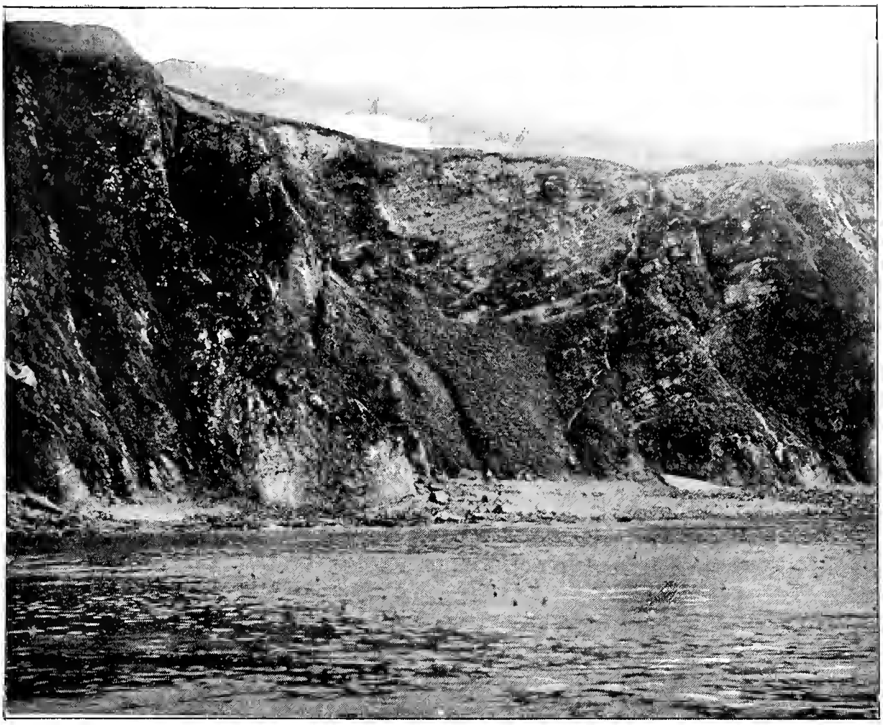
KARABELNOYE ROOKERY, COPPER ISLAND, LOOKING EAST TOWARD VODOPADSKI MYS, FROM PHOTOGRAPHIC STATION No. 2 (MAP, PLATE 12). AUGUST 1, 1895.



KARABELNI STOLP, COPPER ISLAND. FACSIMILE OF PENCIL SKETCH BY THE AUTHOR, JULY 3, 1883, FROM PHOTOGRAPHIC STATION No. 1 (PLATE 38*b*), TO SHOW DISTRIBUTION OF SEALS.

KARABELNOYE ROOKERY, COPPER ISLAND. FACSIMILE OF PENCIL SKETCH BY THE AUTHOR, JULY 3, 1883, FROM PHOTOGRAPHIC STATION No. 3 (PLATE 39), TO SHOW DISTRIBUTION OF BREEDING SEALS.

KARABELNOYE ROOKERY, COPPER ISLAND. FACSIMILE OF PENCIL SKETCH BY THE AUTHOR, JULY 3, 1883, FROM PHOTOGRAPHIC STATION No. 2 (PLATE 40), TO SHOW DISTRIBUTION OF BREEDING SEALS.



a.—Bolshaya Bukhta, from extreme end of Karabelni Stolp.
From a photograph by N. Grebnitski, August 1, 1895.

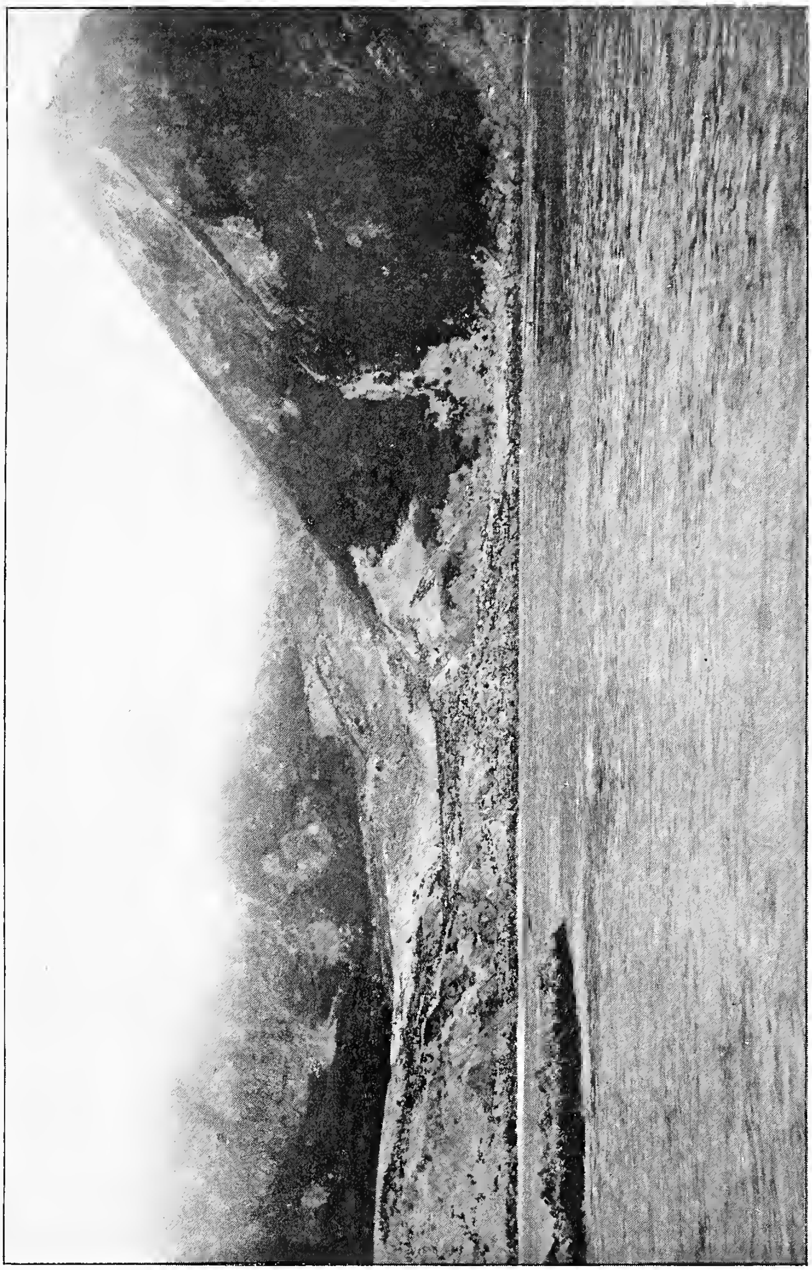
b.—Drive steps, Stolbovaya Bukhta, from Photographic Station No. 5 (map, plate 12).

KARABELNOYE ROOKERY, COPPER ISLAND.

DRIVE STEPS AND WATERFALL, VODOPAD, KARABELNOYE ROOKERY, COPPER ISLAND.

PALATA, COPPER ISLAND, FROM ZAPADNI.
From a photograph by N. Grebnitski, August 7, 1895.

PALATA REEF, COPPER ISLAND.
Photograph by N. B. Miller, June 4, 1892.



PALATA ROOKERY, COPPER ISLAND, FROM A ROCK OFF THE ROOKERY, LOOKING UP THE GULLY. AUGUST 2, 1895.

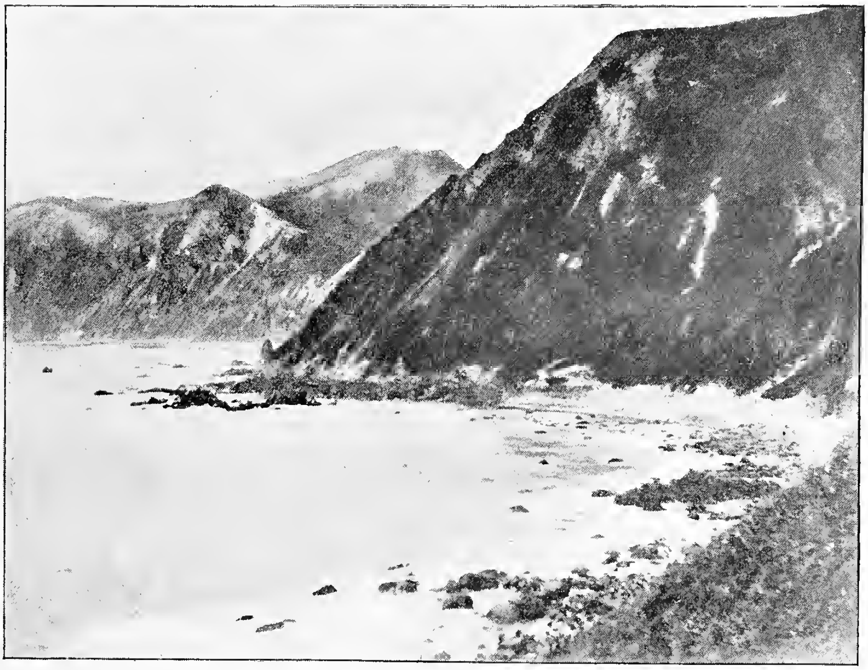
PALATA ROOKERY, COPPER ISLAND, FROM SAME STANDPOINT AS PLATE 48, LOOKING TOWARD SABATCHA DIRA. AUGUST 2, 1895.

PALATA ROOKERY, COPPER ISLAND, FROM NEARLY SAME STANDPOINT AS PLATE 55, LOOKING DOWN THE GULLY. AUGUST 7, 1895.

PALATA ROOKERY, COPPER ISLAND, FROM HILL MARKED "806" FEET ON MAP, PLATE 14. AUGUST 7, 1895.

PALATA ROOKERY, COPPER ISLAND. FROM A SKETCH BY THE AUTHOR, JULY 16, 1883, FROM SAME STANDPOINT AS PLATE 51, TO SHOW DISTRIBUTION OF SEALS.

a.—Palata Rookery, Copper Island Standpoint a little farther to the right and lower down than plates 51 and 52.



b.—Zapadni Rookery, Copper Island. Standpoint lower down than plate 54*a*.

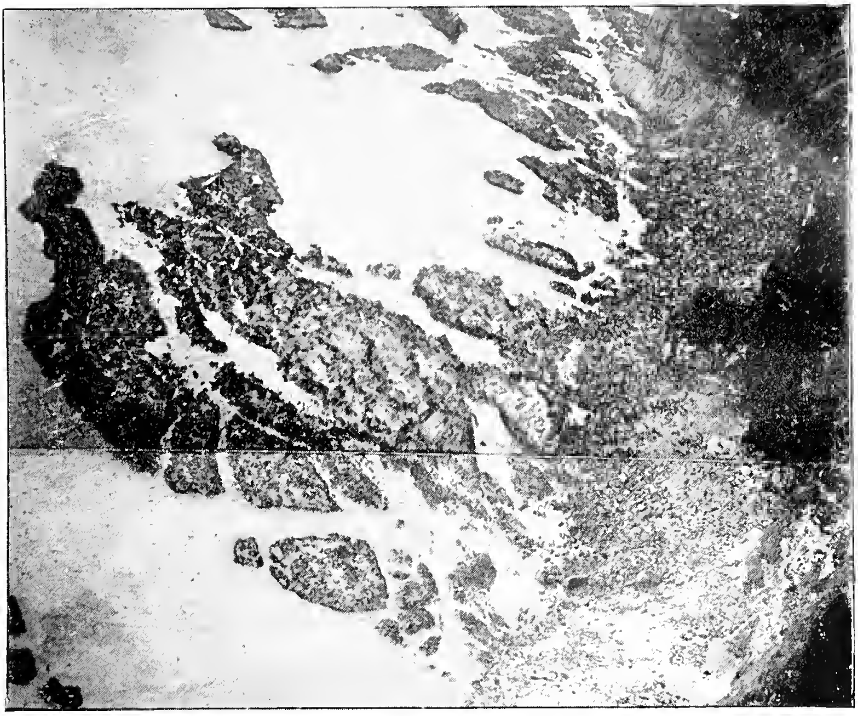
COPIES OF PHOTOGRAPHS BY COLONEL VOLOSHINOF, TO SHOW DISTRIBUTION OF SEALS IN 1885.

a.—ZAPADNI ROOKERY, COPPER ISLAND, FROM SAME POINT AS PLATE 51. AUGUST 7, 1895.

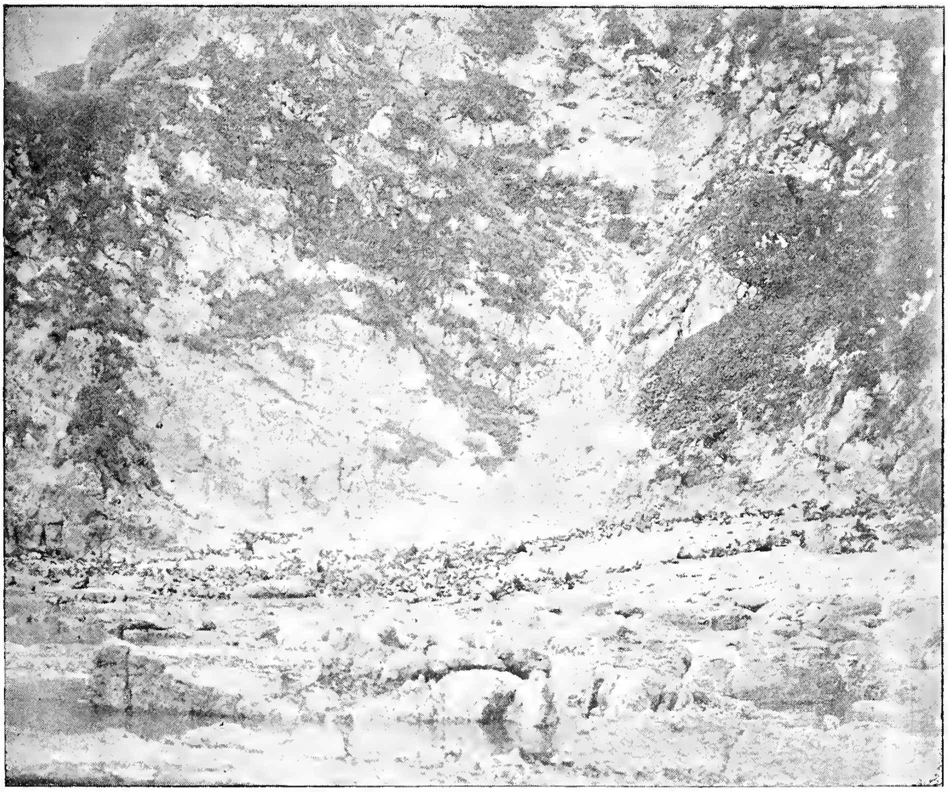
b.—URILI KAMEN ROOKERY, COPPER ISLAND, FROM PERESHEYEK. AUGUST 3, 1895.

ZAPALATA ROOKERY, COPPER ISLAND, LOOKING EAST TOWARD STOLBI. AUGUST 7, 1895.

ZAPALATA ROOKERY, COPPER ISLAND, LOOKING WEST TOWARD END OF PALATA. FROM SAME POINT AS PLATE 55. AUGUST 7, 1895.



a.—ZAPALATA ROOKERY, COPPER ISLAND. FROM A PHOTOGRAPH BY COLONEL VOLOSHINOF TO SHOW DISTRIBUTION OF SEALS IN 1885. SAME STANDPOINT AS PLATE 56.

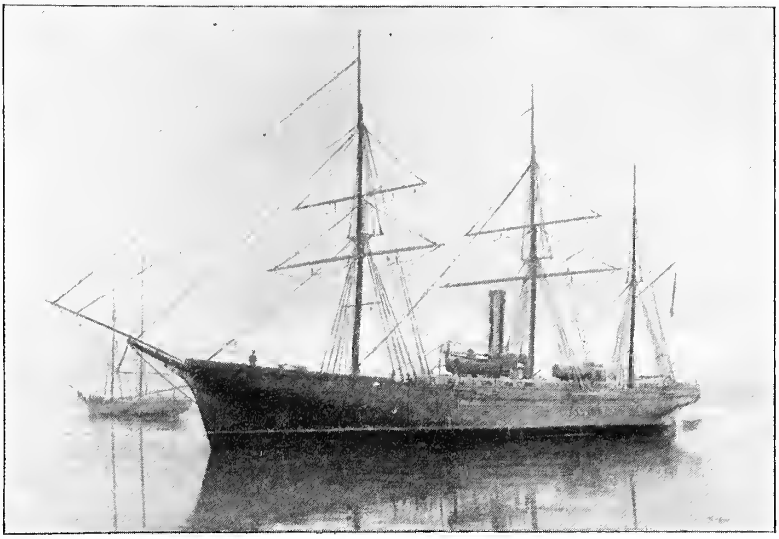


b.—SIKATCHINSKAYA BUKHTA ROOKERY, COPPER ISLAND, FROM A ROCK OFF THE ROOKERY.
Photograph by N. Grebnitski, August 2, 1895.

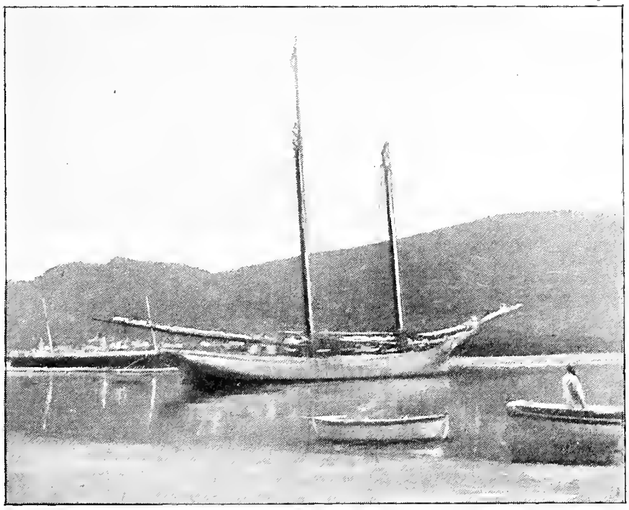
a.—DRIVEWAY FROM ZAPADNI ROOKERY, COPPER ISLAND, LOOKING DOWN THE VALLEY. AUGUST 8, 1895.

b.—DRIVEWAY FROM PESTSHANI HAULING-GROUNDS, COPPER ISLAND.

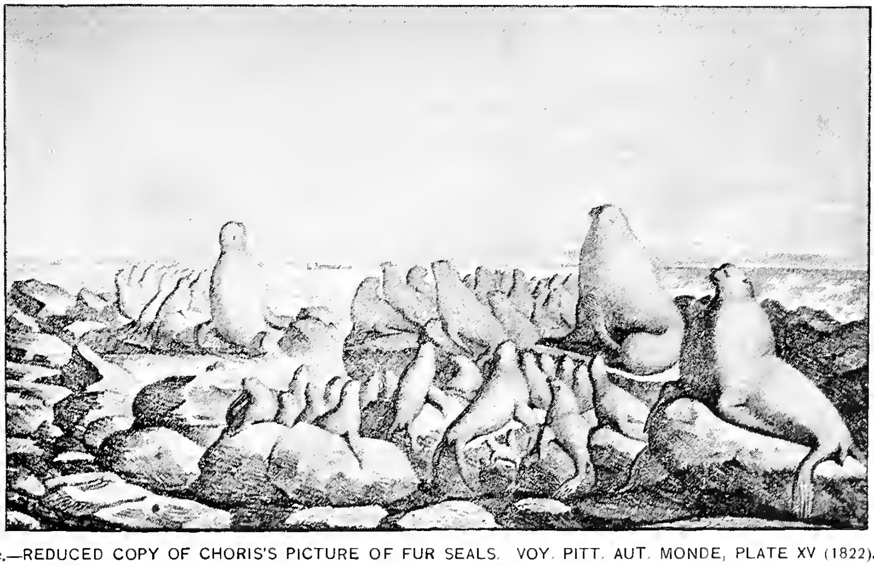
c.—PESTSHANI SALT-HOUSE, NEAR GLINKA VILLAGE, COPPER ISLAND.



a.—HUTCHINSON, KOHL, PHILIPPEUS & CO.'S STEAMER ALEKSANDER II.

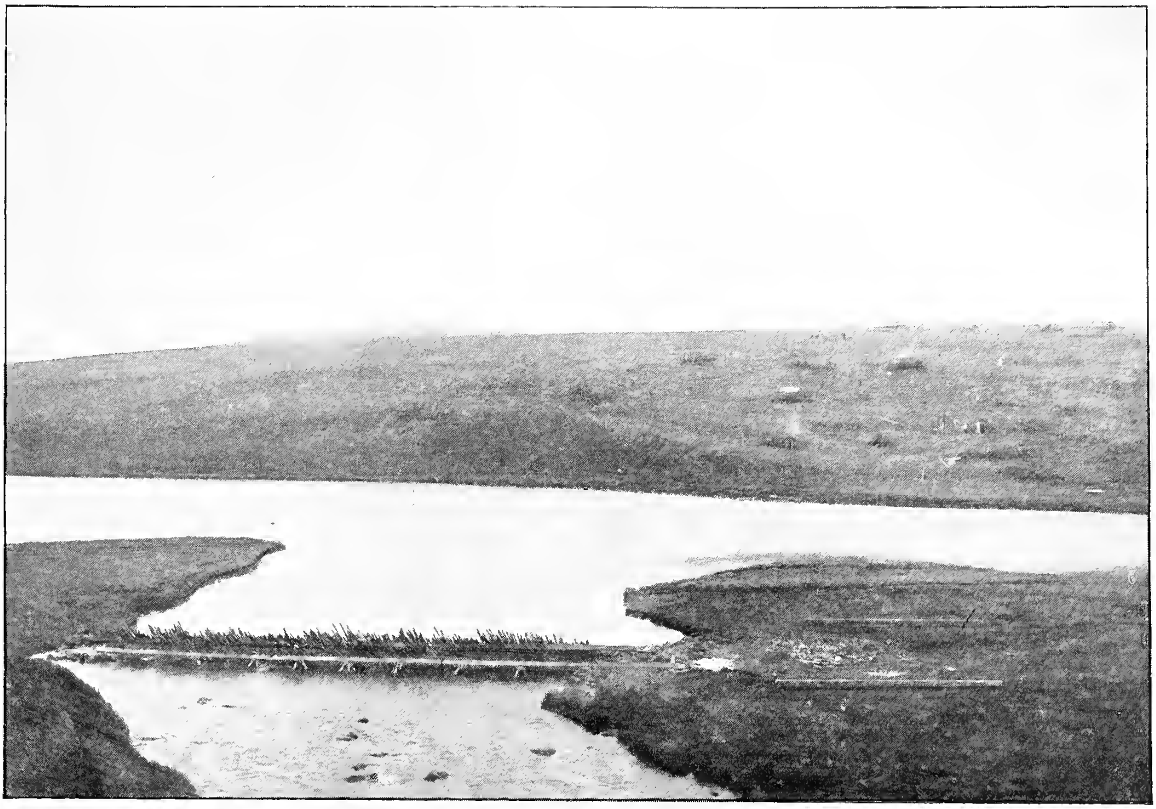


b.—RUSSIAN SEAL SKIN COMPANY'S SCHOONER BOBRIK, CAPT. D. GRŒNBERG.

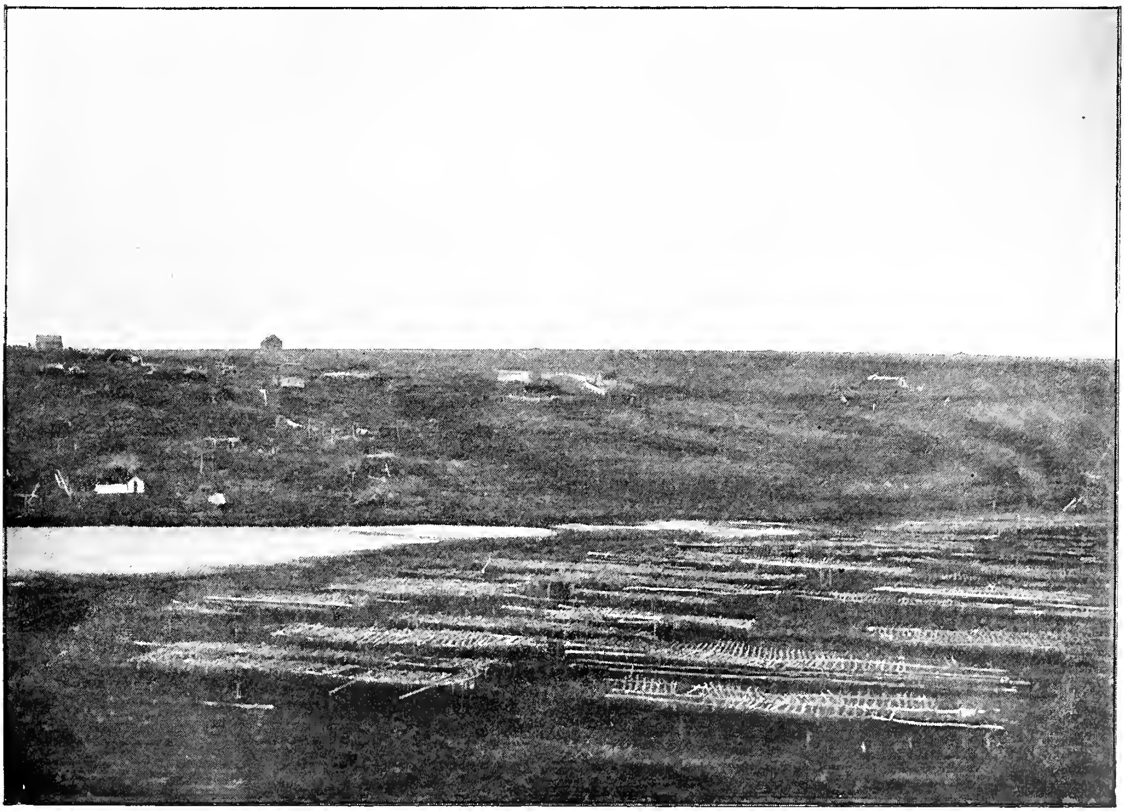


c.—REDUCED COPY OF CHORIS'S PICTURE OF FUR SEALS. VOY. PITT. AUT. MONDE, PLATE XV (1822).

SALMON WEIR (ZAPORR), SARANNA RIVER, BERING ISLAND.



a.—Western half, with salmon weir.



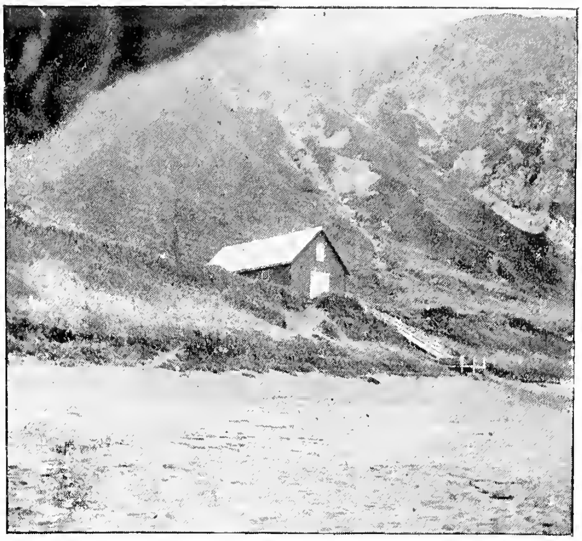
b.—Eastern half, with scaffolding for drying salmon.

SARANNA VILLAGE, BERING ISLAND.

a.—Native dragging along a seal which is too tired to move.

b.—A baby skin-carrier.

DRIVE FROM ZAPADNI, COPPER ISLAND, AUGUST 8, 1895; EARLY MORNING; DRIZZLING RAIN.

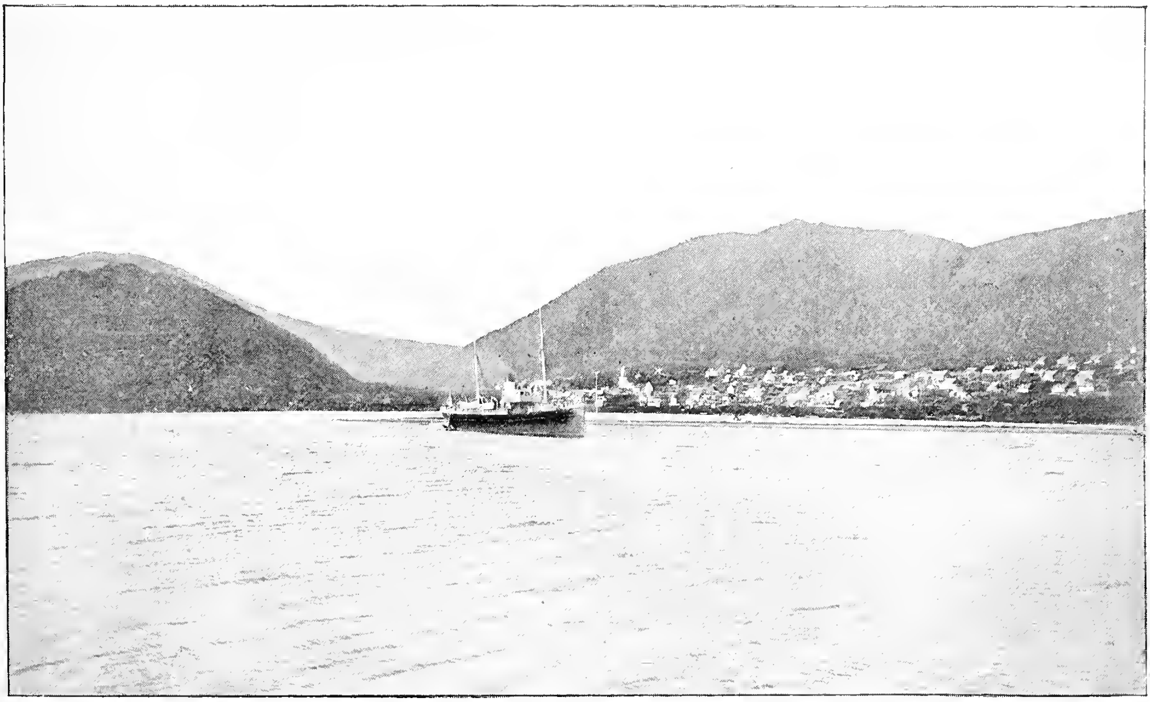


a.—SALT-HOUSE AT POPOFSKI, NEAR KARABELNI VILLAGE, COPPER ISLAND.

b.—SEALS SLIDING DOWN THE LAST EMBANKMENT, GLINKA VILLAGE, COPPER ISLAND. DRIVE AUGUST 8, 1895.

DEAD SEAL PUPS IN WINDROWS, REEF, NORTH ROOKERY, BERING ISLAND, SEPTEMBER 16, 1895.

a.—From hill behind the town.



b.—From Russian Seal Skin Company's wharf.

PETROPAULSKI, KAMCHATKA.

a.—Russian Seal Skin Company's wharf, magazines, and steamer Kotik, Capt. C. E. Lindquist.

b.—Headquarters of Russian Seal Skin Company.

PETROPAULSKI, KAMCHATKA.

A REPORT

UPON

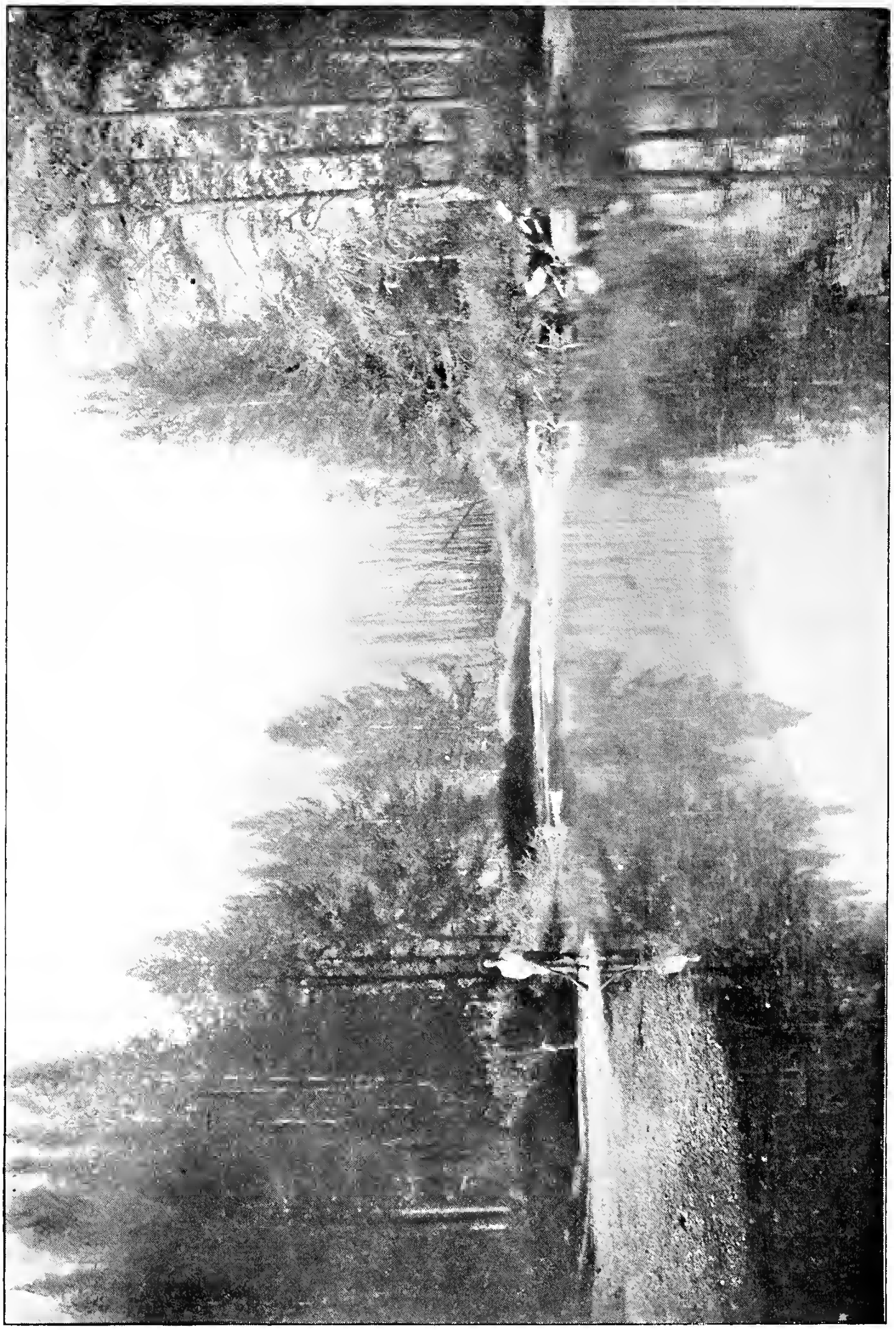
SALMON INVESTIGATIONS IN THE HEADWATERS OF THE COLUMBIA RIVER, IN THE STATE OF IDAHO, IN 1895,

TOGETHER WITH

NOTES UPON THE FISHES OBSERVED IN THAT STATE IN 1894 AND 1895.

BY

BARTON WARREN EVERMANN, Ph. D.,
Ichthyologist of the United States Fish Commission.



MOUTH OF INLET TO ALTURAS LAKE, IDAHO.

The last 3 miles of this inlet contains important spawning beds of both forms of the Redfish or Blueback Salmon (*Oncorhynchus nerka*).

2.—A REPORT UPON SALMON INVESTIGATIONS IN THE HEADWATERS OF THE COLUMBIA RIVER, IN THE STATE OF IDAHO, IN 1895, TOGETHER WITH NOTES UPON THE FISHES OBSERVED IN THAT STATE IN 1894 AND 1895.

By BARTON WARREN EVERMANN, Ph. D.,
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The investigations concerning the physical and natural-history features of the Columbia River basin begun by the Commission in 1892 were continued in 1895. The work in 1894 and 1895 was directed chiefly to an inquiry into the spawning habits of the redfish (*Oncorhynchus nerka*) and the chinook salmon (*O. tschawytscha*).

The preliminary inquiry made in 1894 by Dr. J. T. Scovell and the writer at Big Payette Lake and in the headwaters of Salmon River, the report upon which has been published,[1] indicated that those two localities afford excellent facilities for the study of those two important species at spawning time. They were therefore selected as the field of operations for 1895, and a party was sent to each.

Mr. Thomas M. Williams, of Stanford University, was sent to Big Payette Lake, where he arrived July 19 and remained until September 25. Prof. Seth E. Meek, of Arkansas State University, and Mr. Norman B. Scofield, of Stanford University, were sent to the headwaters of Salmon River. They arrived at Sawtooth July 17, established camp on Pettit Lake July 22, and were joined August 9 by Dr. Oliver P. Jenkins and the writer. On August 28 the camp was moved to Alturas Lake, and on September 18 it was again moved to Alturas Creek in the valley near Salmon River. Dr. Jenkins remained in the field until August 29 and Professor Meek until September 12. On September 11 Mr. William Barnum, of the Fish Commission, joined the party, and on September 24 the work was brought to a close.

Mr. Williams's field of operations was limited practically to Big Payette Lake and its inlet and outlet, while that of the other party covered much more territory, embracing, as it did, the entire group of Redfish Lakes, except Stanley Lake.

As already stated, the inquiry made in 1894 showed that both the redfish and chinook salmon have important spawning-grounds in each of these regions, and it was to these two species that the present investigations were primarily directed. The opportunity to study the other species of fishes found in those waters was not, however, neglected, and a large amount of information bearing upon their habits and geographic distribution was obtained.

There are, as is well known, two forms of the redfish which breed in the inlets to certain lakes in Idaho. These two forms seem to agree in habits and in all structural characters except size, and apparently constitute a single species. The individuals of

[1] A Preliminary Report upon Salmon Investigations in Idaho in 1894, by Barton W. Evermann. <Bull. U. S. Fish Comm. for 1895, 253–284.

one form weigh from $3\frac{1}{2}$ to 6 pounds, while those of the other and more numerous form weigh almost invariably one-half pound each.

The principal problems concerning this fish, the solutions of which were sought in our investigations, may be stated as follows:

1. Do both the large and the small redfish come up from the sea, or are the small ones a landlocked form, inhabiting the lakes except during the spawning season, when they run up into the inlets?
2. If the redfish are anadromous, when do they reach their spawning-grounds?
3. Where and how do the redfish receive the mutilations noticed upon them when spawning?
4. What are their spawning habits, particularly when on the spawning-beds?
5. Do the fish return to the lake or the sea after spawning, or do they all die?
6. Where do the young redfish stay?
7. What is the definite location of the present spawning-beds, and what is their condition?

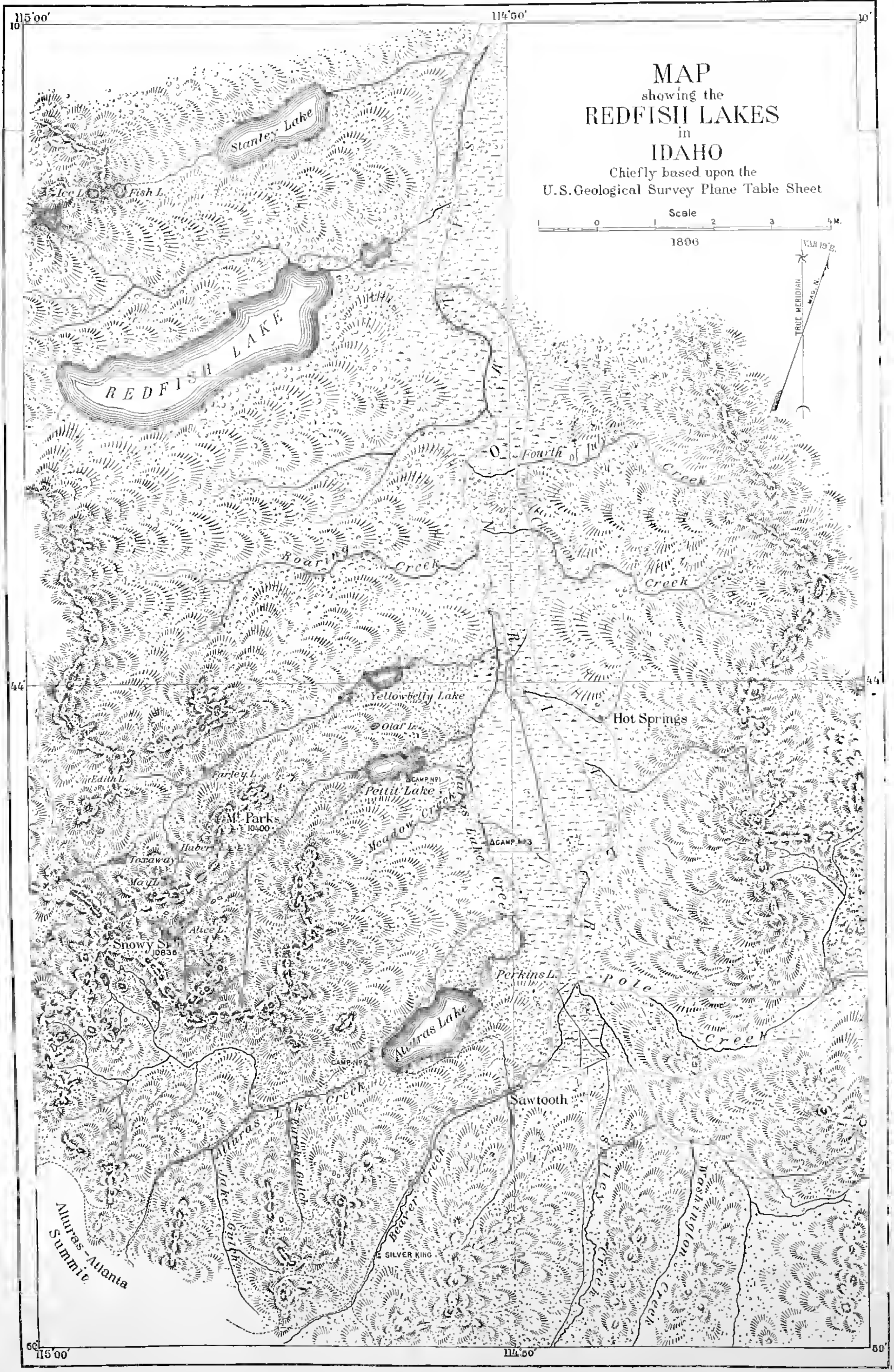
The chinook salmon also have important spawning-grounds in the upper Salmon River basin and in Payette River, and definite information regarding this species was also desired.

1. Where are its spawning-grounds, and what their extent and present condition?
2. When does it reach its spawning-grounds?
3. What is the condition of the fish when they first arrive? Are the mutilations, frayed-out fins, and sores the result of the long journey from the sea, or are they all received while on the spawning-beds?
4. What are the habits of this fish while spawning?
5. What becomes of them after they have finished spawning?
6. How long do the young remain in the vicinity of the spawning-beds?

In order to study these various problems in the most satisfactory manner, a camp was established July 22 on Pettit Lake. This location was thought to be such as would enable the different members of the party to keep a close watch upon the outlet and inlets of Pettit Lake, the outlet and inlet of Alturas Lake, Alturas Creek, and a portion of Salmon River. Gill-nets were set as follows: One of $7\frac{1}{2}$-inch mesh in Salmon River just above the mouth of Alturas Creek, and one of same kind in Alturas Creek about a mile above its mouth. These were meant for the chinook salmon and the large redfish. A $2\frac{1}{2}$-inch-mesh net was placed in the outlet and one in the main inlet of Pettit Lake, and one in the outlet and one in the inlet of Alturas Lake. These four were intended for the redfish, particularly the small form. If the salmon and redfish had not yet come, the nets below the lakes would tell us of their arrival. The nets in the inlets would tell us when the redfish began ascending the inlets from the lakes. These various nets would also enable us to determine whether either or both species return downstream after spawning.

It was soon demonstrated that the nets were too remote from each other to permit daily visits being made to all. In consideration of this fact and the early solution of certain of the problems, the locations of some of the nets were changed. And after the fish had appeared at any particular net, and the time of their arrival was thus determined, that net was lifted for a time, to allow the fish to go on to their spawning-beds. Visits were made to all the nets at least as often as every other day.

On August 28 we moved camp from Pettit Lake to the inlet of Alturas Lake, in order that the redfish in that stream might be watched continuously. Occasional


MAP
showing the
REDFISH LAKES
in
IDAHO
Chiefly based upon the
U.S. Geological Survey Plane Table Sheet
Scale
1896
115°00'
114°50'
44°
Stanley Lake
Ice L.
Fish L.
REDFISH LAKE
Fourth of July Creek
Roaring Creek
Champion Creek
Yellowbelly Lake
Olaf L.
Hot Springs
Edith L.
Farley L.
Pettit Lake
CAMP No. 1
CAMP No. 3
Mt. Parks
10400
Meadow Creek
Alturas Lake Creek
Haber
Tosaway
May L.
Alice L.
Snowy Sr.
10836
Perkins L.
Pole Creek
Alturas Lake
CAMP No. 2
Sawtooth
Alturas Lake Creek
Eureka Gulch
Jake Gulch
Beaver Creek
SILVER KING
Smiley Creek
Washington Creek
Alturas-Atlanta Summit
TRUE MERIDIAN
MAG. N.

visits were still made to Pettit Lake, Alturas Creek, and Salmon River, thus enabling us to keep informed as to the progress of events in those waters.

At Big Payette Lake similar methods were employed by Mr. Williams. Gill nets were set in the outlet and in the inlet, and inspected from time to time as required.

The detailed operations of these various nets will be given in connection with the discussion of each particular species of fish taken in them.

In the present connection, the following brief summary of the more important results of these investigations may be given:

1. The redfish, both large and small, had reached these lakes prior to July 20, when our observations began. While the proof that the large form is anadromous may be regarded as conclusive, the evidence that the small one comes up from the sea is not complete. It seems probable that both are anadromous, but, so far as the Idaho lakes are concerned, the small form has not been proved to be so.

2. If the redfish, large and small, are anadromous they reach the Redfish Lakes, in some years at least, earlier than July 20.

3. The mutilations, sores, fraying out of fins, etc., are not received en route to the spawning-grounds, but are practically all received subsequent to reaching them.

4. The redfish all die soon after spawning.

5. The young redfish remain in the lakes and connecting waters for at least one year from the time when the eggs were spawned.

6. The chinook salmon arrived on or about July 24, and were practically without mutilations or sores.

7. All the chinook salmon which come to these waters die after spawning.

8. The young chinook salmon appear to remain for one year after the eggs are laid, near where they were hatched.

THE REDFISH LAKES.

The group of lakes known collectively as the "Redfish Lakes" is situated in the western part of Blaine and Custer counties, Idaho. They all lie on the west side of the Salmon River Valley at the east base of the Sawtooth Mountains. The center of the group is, approximately, in latitude 44° north and longitude 115° west.

The principal lakes of the group are known as Alturas, Pettit, Yellowbelly, Redfish, and Stanley lakes. Besides these there are two or three smaller ones at the same altitude, while at the heads of their inlets at greater elevations are a great many small lakes. All of these lakes empty their waters into Salmon River and really constitute the headwaters of that stream. Each of the larger lakes lies in a basin scooped out by glacial action. Across the canyon at the lower end of each lake is a broad terminal moraine through which the outlet has cut its way.

The general direction of the longer axis of each of these lakes is northeast and southwest, and on either side are high ridges extending from the Sawtooth Mountains into the edge of the valley. These ridges are the immense lateral moraines of the ancient glaciers which formed the canyons in the mouths of which the lakes now lie. The larger, higher morainic ridges have a granite axis or core, but the smaller ones are apparently composed entirely of morainic material. In most cases the ridge on the right shore of the lake is lower than the one on the opposite side.

In the main canyon and the branches which open into it flow the inlet streams and their many smaller tributaries. These streams have their sources in the fields

of snow which lie on the more protected slopes among the high and rugged peaks of the Sawtooth range. The elevation of Salmon River Valley in its upper portion is 7,000 to 7,300 feet, while that of the larger lakes is about 7,200 feet. The Sawtooth range is a group of remarkably rugged mountains, from whose different slopes the streams flow in all directions. On the north are the creeks which form the middle fork of the Salmon; on the east are the headwaters of the main fork of the Salmon; on the southeast and south are Big Wood River and the streams which go to make the south fork of Boise River; while the west slopes furnish the water supply for the north fork of the Boise and the east fork of the Payette.

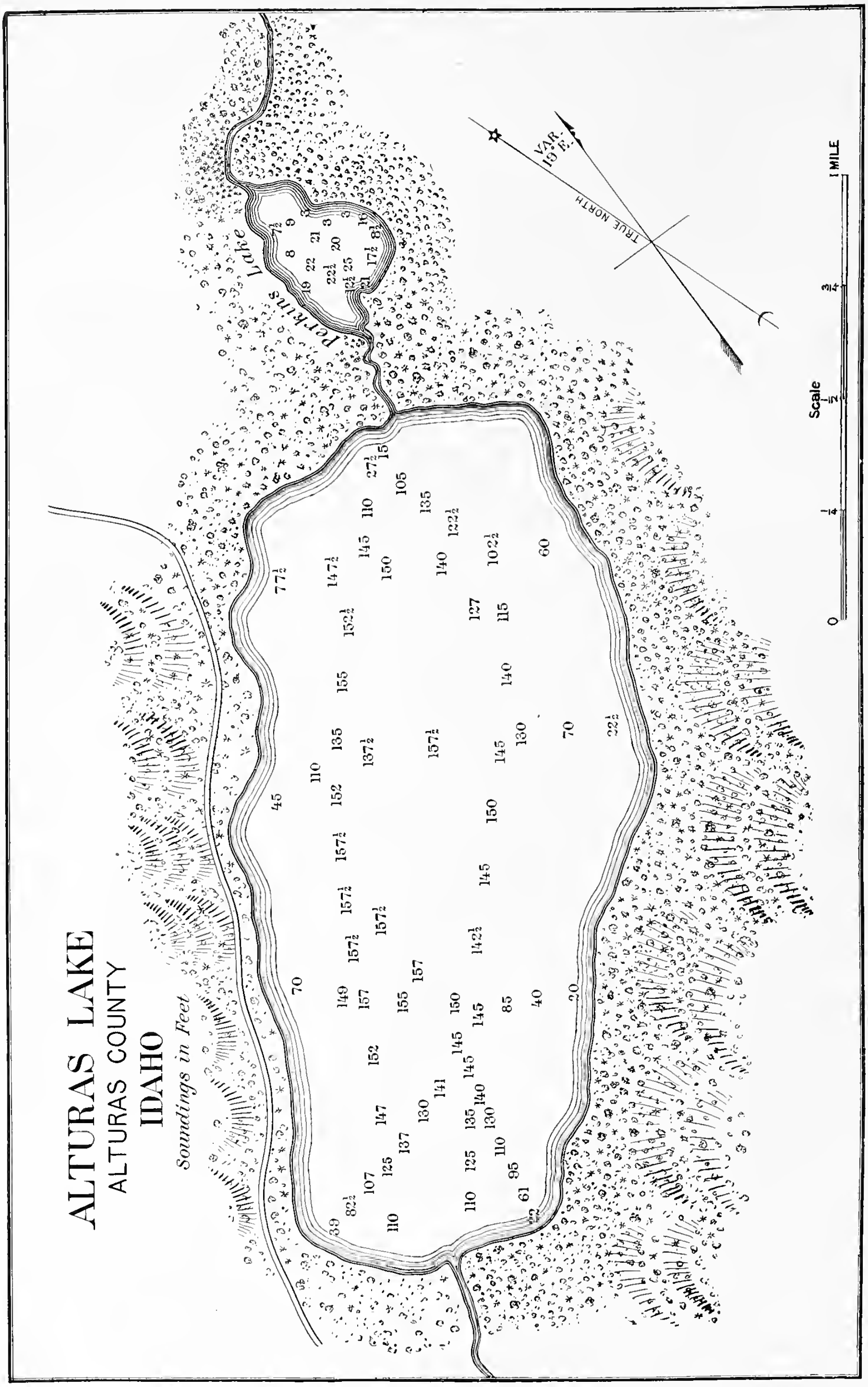
The general direction of this range is north and south. The peaks are extremely precipitous and often consist of a series of sharp needles or spires whose summits are inaccessible. These sharp needles give the range a very jagged outline, as seen from a distance, and suggested the very appropriate name which the range bears. These peaks are, in most cases, 10,000 to 10,800 feet high. The highest one, whose elevation has been determined by Mr. E. T. Perkins, jr., of the United States Geological Survey, is known as Snowyside and is 10,836 feet above the sea.

The evidences of glacial action are on every hand and on a grand scale. Wherever the bottom or sides of the old glacier beds are exposed and composed of rock that does not readily disintegrate, the striations and grooves are distinctly retained. These markings are, however, in many places obscured by disintegration or covered up by talus or the enormous amount of material brought down into the canyons by snowslides, which are very frequent in these mountains. There are also numerous mutton-backs or *roches moutonnées* in the upper and middle parts of these canyons. Some of them are very large and, when not covered by débris, show in a remarkable degree the markings characteristic of glacial regions.

The moraines for the most part appear to have been but little disturbed since their first formation, and remain to-day essentially as left by the retreating glaciers. Enough disintegration has occurred, however, to form sufficient soil among the bowlders to give footing to a fairly heavy growth of timber. As a rule, all of the ridges on the west side of Salmon Valley are pretty heavily wooded. The higher mountains and the more rugged peaks are, of course, above timber line, and in some cases the lower ends of the moraines extending into the valley have few or no trees.

These moraines have been so little altered or modified that they still show with great clearness all the intricacy of detail of the moraines of great glaciers. In some positions near the main peaks the lateral moraines are immense naked ridges of clean angular bowlders with no sign of soil or vegetation upon them. They appear as if the ice of the glacier had but recently melted away from them. The larger lateral moraines extend long distances into and down the Salmon River Valley. These ridges are, as a rule, heavily timbered with Murray pine and Douglas fir, with here and there a clump of cottonwoods (*Populus tremuloides*). The forest on these ridges stops as abruptly as do the ridges themselves.

One of the most conspicuous and interesting features of the landscape is seen in these long, densely wooded ridges extending out into the broad, treeless valley of Salmon River. Looking down upon them from any high peak, they appear as long tongues of dark green reaching out into the valley and contrasting strongly with the duller colors of the dry grasses and the sage-brush.



ALTURAS LAKE, IDAHO; ALTITUDE 7,200 FEET.

The inlet to this lake contains important spawning beds of the Redfish or Blueback Salmon (*Oncorhynchus nerka*).

In discussing the fauna and flora of central Idaho, Dr. Merriam gives an excellent account of the forests of this region.[1] He assigns the Sawtooth Mountains and their adjacent and contained valleys to the following life zones:

1. Arctic-Alpine zone, from the upper limit of tree growth or timber line to the tops of the highest peaks. The height of the timber line varies according to slope exposure from 10,000 to 11,000 feet.

2. Subalpine or Timber-line zone, occupying the strip from the upper limit of stunted tree growth down to the upper limit of full-grown, perfect trees. The dwarfed trees growing in this zone are *Abies subalpinus, Pinus albicaulis* and *Picea engelmanni*, and the limits of the zone lie approximately between 10,000 and 11,000 feet.

3. Hudsonian or Spruce zone, lying between 9,000 and 10,000 feet. Its characteristic trees are the same as those of the Subalpine zone, but in this they obtain full and perfect size.

4. Canadian or Douglas fir zone, lying between 7,700 and 9,000 feet. The characteristic trees are the Douglas fir (*Pseudotsuga douglasii*) and the Murray pine (*Pinus murrayana*), with a few of *Picea alba* and *Populus tremuloides*.

5. Neutral or Transition zone, occupying the strip between 6,400 and 7,500 feet altitude, and with the sage-brush (*Artemisia tridentata*) as its most characteristic plant.

That portion of southern Idaho having an elevation of less than 6,400 feet and comprising the great Snake River plains, he assigns to his Upper Sonoran zone.

The forests about the Redfish lakes are composed almost entirely of the coniferous species already mentioned. In the immediate vicinity of the lakes is the Murray pine and occasional examples of Douglas fir and white spruce, though these two species are most abundant on the slopes some distance above the lakes. A few small, white-bark pines were seen near Alturas and Pettit lakes, but this species reaches its maximum size and abundance in the Hudsonian or upper timber zone, as stated by Dr. Merriam.

This region has never been mapped, even with approximate correctness. The United States Geological Survey is now engaged in making a topographical survey of this portion of Idaho. Through the kindness of Mr. Henry Gannett, chief topographer of the Survey, and Mr. E. T. Perkins, jr., topographer in charge of the Idaho field work, the Commission has been permitted to use the plane-table sheet of the Sawtooth region, and the accompanying map is based upon the Survey's work. That portion of the map north of Yellowbelly Lake is approximately correct only as to general features, as that region has not yet been examined by the Survey. Our own observations did not extend north of Yellowbelly Lake except in Salmon River Valley and in the immediate vicinity of Redfish Lake.

The following pages give detailed descriptions of the different lakes which we examined.

ALTURAS LAKE.

This lake, which is sometimes called Sawtooth Lake, is situated about a mile[2] northwest from the village of Sawtooth, from which it is separated by a densely wooded morainic ridge which rises some 600 feet above the lake. The greatest width of the lake is about four-fifths of a mile, and its greatest length about 2 miles. The general direction of its longer diameter is nearly northeast and southwest. The shore line is quite regular, there being no considerable bays or coves. Throughout the upper 1½ miles of the lake the opposite shores are approximately parallel and, as already stated, about four-fifths of a mile apart.

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[1] North American Fauna, No. 5. The elevations given by Dr. Merriam, referred to here, are all somewhat too great.

[2] The distance by trail over the ridge is about 3 miles.

Of course there are numerous little irregularities in the shore line, but they are scarcely noticeable to the observer standing at either end of the lake or looking down upon it from the mountain ridge to the northwest.

The setting of Alturas Lake is extremely beautiful. On the right side is a heavily wooded ridge rising gently from the water's edge to a height of 400 to 600 feet. In some places the shore is comparatively level for some rods back from the .ake; in two or three places there are small, level meadows, and a fairly good trail extends the entire length of the lake on the left side. The immediate shore is, throughout most of its extent on the right side, covered with a heavy growth of bushes, chiefly alder, but with a good many willows and a few cottonwoods.

The trees nearest the water are nearly all Murray pine, but there are a few Douglas fir (*Pseudotsuga douglasii*) and spruce (*Picea engelmanni*), and an occasional small piñon (*Pinus albicaulis*). There are also a few small, stunted junipers. In the more level, moist places, firs and spruce are abundant, often growing to a height of 100 feet or more and a diameter of 2 or 3 feet, but the usual size is much smaller.

On the more sandy, drier portions of the shore and on the sides and top of the ridge the Murray pine is the principal tree. It is usually a tall, slender tree, less than a foot in diameter, exceedingly straight, and 25 to 100 feet high. In the moist places on the hillside, where the ground is springy or where a small stream comes down, there are often considerable clumps of cottonwoods or quaking asps. Beneath the trees are grasses and numerous species of flowering plants and shrubs. On the drier, more open places the scraggy, aromatic sage (*Artemisia tridentata*) and the rich, pleasing blue of the lupine (*Lupinus argenteus*) are seen in abundance; where it is more moist and somewhat shaded the rank and gorgeous *Epilobium* is the most conspicuous plant in early autumn, while in the yet more shaded and damper tangle are found the dark-blue aconite (*Aconitum columbianum*) and brilliant patches of the beautiful shooting star (*Dodecatheon jefreyi*), whose delicate flowers wither and die early in July or August. And among the grasses in the level, marshy meadow places the large, deep-blue gentian (*Gentiana affinis*), with its short stem, can be seen in profusion and perfection long after the frosts and the first snows have come.

Among the shrubs the service-berry (*Amelanchier alnifolia*), the small, red whortleberry (*Vaccinum myrtilloides microphyllum*), and the curious *Lonicera involucrata* were the most interesting. The first of these is rarest of all and, though growing to a height of 6 to 10 feet, its fruit rarely ripens in this locality, the summers being too short. The most abundant is the little whortleberry, with its pale-red berries, which ripen in early August and upon which the fool-hens, robins, and bear delight to feed.

On the northwest side of the lake is a rugged, granite mountain ridge, rising 1,000 to 1,500 feet above the lake. This originally formed the left shore of the large glacier which, coming down from the Atlanta summit, plowed out this valley and formed Alturas Lake. This mountain is rocky and precipitous, and has but little timber upon the side toward the lake. Immense snowslides have from time to time come down the side of this mountain, carrying everything before them into the lake. Down several rocky gulches flow small but turbulent streams during times of rain or melting snows. But once the rains have ceased or the snows have melted, all but two or three of these streams dry up entirely. There are two or three which are fed partly by springs, and they continue to flow throughout the dry summer. Along this side of the lake there is but little timber, except near the lower end, where there is a broad,

level tract, densely covered with a growth of small Murray pines, through which a forest fire has recently raged, killing nearly every tree.

A fairly good wagon road extends from Salmon Valley up this side of the lake to the inlet. The outlet of the lake is through a heavily wooded valley, where the Murray pine is the prevailing tree.

At the upper end of Alturas Lake is the narrow valley of the inlet which will be described more fully later on.

Depth.—A great many soundings were made in this lake, the majority of which are indicated on the accompanying map. Six principal lines were run across the lake and soundings taken at every 100 strokes with the oars, that is, about every 400 feet. As may be seen from the map, the lake is most shallow and grows deep most gradually on the right side. The left side becomes deep very close to shore. At the upper and lower ends, also, the depth increases quite rapidly. The greatest depth found was 157½ feet, which was near the middle of the left side of the lake. There seems to be here a basin of considerable extent, ranging in depth from 150 to 157½ feet.

The left bank is rocky and in places precipitous; the lower end and the right side are covered with coarse gravel, while at the upper end the bottom is of fine sand as far out as bottom can be seen.

The water of the lake is very pure and clear, and, when the surface is not disturbed, one can see bottom at a depth of 40 feet and can detect the presence of small fishes at a depth of 30 feet or more.

Temperature.—The water of this lake is very cold and does not differ appreciably from that of Pettit Lake. Our camp was not at any time so situated as to make it practicable for us to take temperature observations on Alturas Lake at regular intervals. The surface temperature at 9.30 a. m., August 10, was 61°, and at 4 p. m. was 63°. It did not vary greatly from these figures during the last half of July and up to the 22d of August. At that date it began to grow gradually colder and was down to about 59° by September 22. The bottom temperature was found to be from 3° to 8° colder than that at the surface, varying with the depth. The lowest temperature was found to be 54°, at a depth of 157 feet.

Vegetation in the lake.—In most places this lake is comparatively free from plant life. While there is considerable bottom vegetation in some places it does not anywhere reach the surface, except in a limited area in shallow water at the head of the lake. About the mouth of the inlet, beginning on the sandy bottom in water 4 or 5 feet deep and 10 to 20 feet from shore, and continuing out to a depth of 60 feet or more, is a thick, rank growth of vegetation, the principal species being *Potamogeton perfoliatus lanceolatus*, *Potamogeton zosteræfolius*, *Potamogeton amplifolius*, a species of *Myriophyllum*, a *Nitella*, and a *Chara*. This growth seems to extend entirely across the upper end of the lake at varying distances from the shore, but is always confined to the fine sand bottom, and apparently between 4 feet and about 60 feet in depth. More extended observations than we were able to carry on will probably show that other parts of the lake possess similar patches of vegetation, particularly along the right side. These masses of vegetation fill, of course, an important place in the biology of the lake. Harboring, as they do, the great bulk of the food of most of the species of fishes which live in the lake, here will be found minnows, suckers, and young *Salmonidæ* in greatest abundance. Indeed, nowhere else in the lake did we find fishes of any kind in any considerable numbers.

Crustacea, etc.—A small surface tow-net was used a few times and the lower forms of life found to be abundant. Only two species of mollusks were found, viz, *Limnæa palustris* in the lake among the vegetation and *Planorbis trivolvis* about the lake.

Reptiles and batrachians.—Only one species of snake (*Thamnophis vagrans*) was seen about this lake. Not more than four or five examples were seen. The only batrachians obtained were *Rana pretiosa*, *Bufo halophilus columbiensis*, and *Hyla regilla*. All these were fairly abundant, particularly the frog.

Muskrats were not uncommon and were sometimes caught in our gill-nets, to which they did considerable damage with their sharp teeth.

Bear were not uncommon about the lakes and along the streams. After the salmon began to die the bear frequented the streams to feed upon the dead or dying fish.

The birds that deserve mention are the following: Horned grebe (*Colymbus auritus*), red-breasted merganser or fish-duck (*Merganser serrator*), and mallard (*Anas boschas*), all of which feed more or less upon the fish. The fish-duck was quite common and fed largely upon the dead redfish, which, as a rule, were kept pretty well cleaned up, the fish-ducks being the principal agent in their prompt removal.

Several species of insects found about these lakes deserve mention. First of all is a large, voracious horsefly (*Theriopleetes sonomensis*), which is excessively abundant in July and August, when it is very annoying to both man and beast. So troublesome was it in some localities that work had to be abandoned. Later in the season this fly proved very good bait for trout and squawfish.

Among the butterflies noted about the lakes were the following:

Neophasia menapia Feld.	Colias eurythene keewaydin Edw.	Lycæna acmon Dbl. Hew.
Argynnis eurynome Edw.	Thecla fuliginosa Edw.	Pamphila uncas Edw.
Grapta zephyrus Edw.	Thecla titus Fabr.	Chrysophanus sp.?
Vanessa antiopa L.		

Trout and squawfish were seen feeding upon several of these species, but the one of greatest interest was *Neophasia menapia*. This small white butterfly was common at all times during the latter part of July and August. On August 15 a remarkable flight was noticed at Pettit Lake. While ascending the ridge on the left shore of Pettit Lake great numbers were seen about 10 o'clock in the morning. The wind was then from the north, and the butterflies were being carried along by it down toward the lake and Salmon River Valley. As we ascended the ridge toward the top of Mount Parks the numbers continued to increase until we had reached a height of about 8,500 feet. Above that altitude the numbers were much reduced, but many were seen even upon the summit, 10,400 feet above the sea. The flight was a most interesting one. A stiff breeze was blowing and the thousands of butterflies were being carried along at a rapid rate. When in protected places they traveled more slowly, but rarely did one stop to rest.

On August 20 a similar flight was witnessed by Mr. Williams at Big Payette Lake. The people in that region had never before noticed this species as being particularly abundant, and regarded this flight as something quite unusual.

For several days following the flight at Pettit Lake this butterfly was unusually abundant in the lower canyons and the valley. While flying across the lakes or streams hundreds would each day drop into the water through fatigue or frayed-out wings, when they would be seized by the trout, squawfish, and perhaps by other species. Mr. Williams noticed small fishes feeding upon them at various times,

particularly on August 28. On August 21, I was astonished to see large numbers of squawfish in Redfish Lake feeding upon these butterflies which were dropping into the water. It was in the evening, when the cooling of the air benumbed the butterflies as they were passing over the lake. The squawfish would strike at the butterfly the moment it fell upon the water, and in a manner much resembling that of the trout. A number of stomachs of trout and squawfish which we examined showed that for some days this butterfly constituted an important part of their food supply.

Inlet.—Alturas Lake has but one inlet of any importance. This enters the lake near the middle of the shore at the upper end. It has its rise in the mountains southwest of the lake about 5 miles, in three principal forks, the middle one of which comes down the steep, rugged canyon from the summit over which passes the trail from Sawtooth to Atlanta. These three forks are all small, and fish of any size are not able to ascend far above their union. The upper portion of the canyon through which this creek flows is narrow, rocky in some places, but usually with a good growth of trees and bushes. Near its head the white-barked pine (*Pinus albicaulis*) is the most abundant, while lower down are the Douglas fir (*Pseudotsuga douglasii*), Engelmann's spruce (*Picea engelmanni*), white spruce (*Picea alba*), and Murray pine (*Pinus murrayana*).

Below the union of the three forks the canyon widens out and in the last 2 miles of its course it is perhaps a mile in average width. The Murray pine grows thickly along the stream, but away from it on the left or west side this tree grows in small clumps or groves with level meadows interspersed. At some places along the inlet the ground is marshy, and there is usually a thick undergrowth of willows and other bushes. In its lower portion this creek is a stream of considerable size, averaging about 25 or 30 feet in width and varying greatly in depth.

On September 17 the measurements of the inlet at its mouth were as follows: Width, 40 feet; average depth, 10.4 inches; average current, $1\frac{1}{7}$ feet per second. This would indicate a discharge of about 18,000 gallons per minute. The stream was measured on the same day at our camp, about half a mile above the mouth, and the following results obtained: Width, $14\frac{2}{3}$ feet; average depth, 10 inches; average current, $3\frac{14}{17}$ feet per second, thus indicating a volume of about 21,000 gallons per minute. The lack of agreement between the two results is probably due to an underestimate of the width and depth at the mouth. The left bank at the mouth overhangs considerably, and sufficient allowance was probably not made for the water running under it. During the early part of the summer the volume of water flowing in this creek was considerably greater, perhaps as much as 28,000 gallons, while at the lowest stage of water the volume is probably not greater than 17,000 gallons. At the time of our measurements the flow was somewhat above low stage, on account of recent rains.

The banks of the creek are low and composed of sandy soil, or in some places of sand or gravel. The stream bed is of moderately coarse gravel on the riffles in the upper portion, and smaller gravel in similar places in the lower portions. But through most of its course the bed is of very fine gravel and sand. Occasionally there is some mud bottom, but this is very rare. The bed is remarkably clean and free from débris or filth of any kind.

The depth of the water in most places varies from a few inches to 2 feet or less, though there are numerous "holes" where the depth varies from 2 to 4 or 5 feet. A deep hole rarely extends entirely across the creek, but lies over toward one bank, the

water always becoming gradually shallow toward the other shore. Except after heavy or continued rains the water is extremely clear, and even after rains it is not turbid enough to prevent one seeing to the bottom of the deepest pools. Ordinarily, when the surface is not rippled by the wind, one can very easily see even very small fishes in any part of the stream where they chance to be; so that one may walk the length of the creek and count all the fishes in it over 3 or 4 inches long, and feel pretty confident he has seen all there really are, if he but scrutinize the stream carefully.

Fishes.—One rarely sees a stream with so few fish in it as this. Species and individuals are both few. Besides the redfish, which come into the creek only at spawning time, the only species of fishes which we saw during a month's observation were the following:

Bull trout (*Salvelinus malma*), not more than a dozen.

Chinook salmon (*Oncorhynchus tschawytscha*), a few young, none over 6 inches long.

Minnow (*Leuciscus baltcatus*), a few seen occasionally.

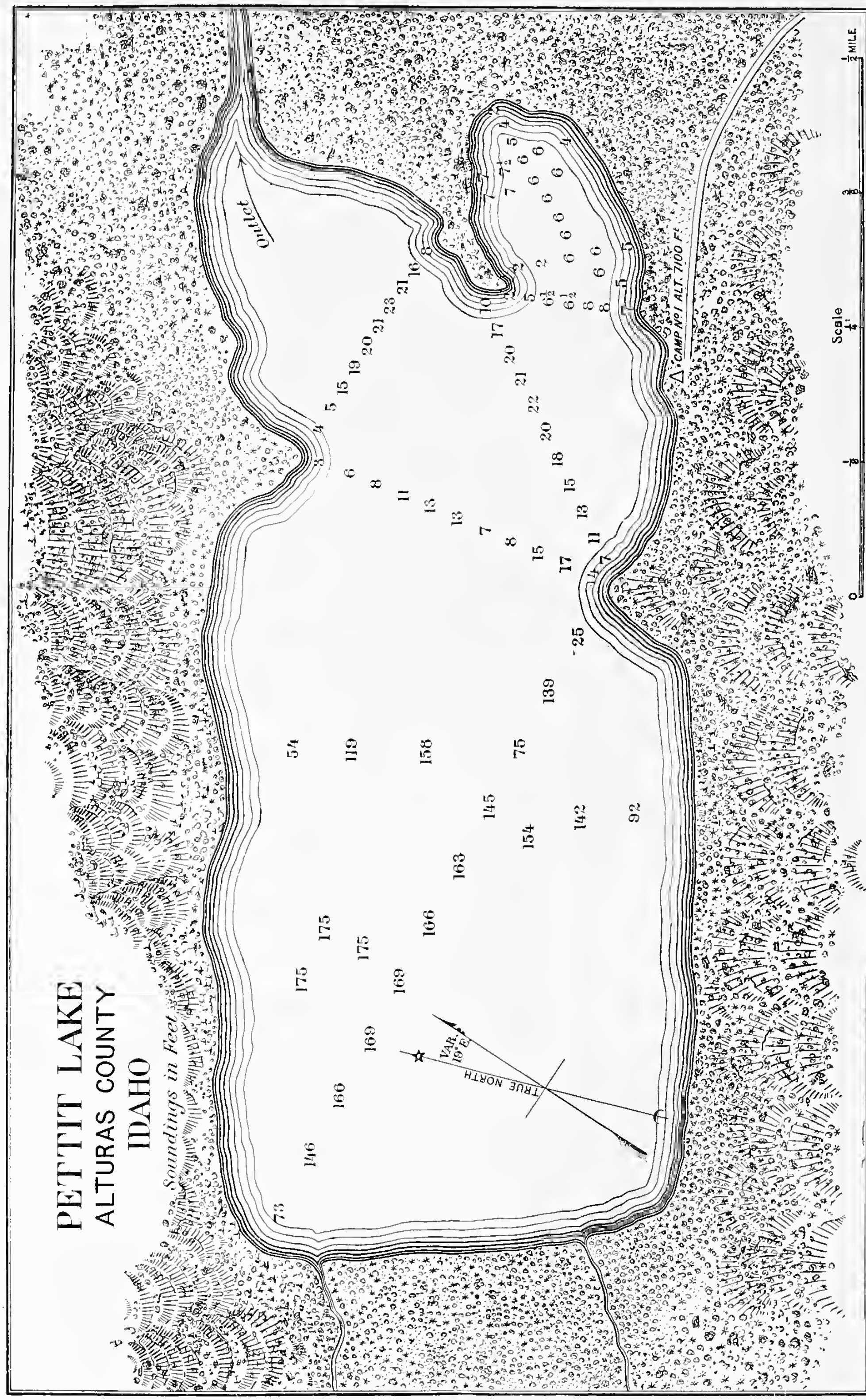
Young whitefish and young suckers probably run up into the inlet, and the blob may also do so now and then, but we never saw these species there.

Cut-throat trout should also be found there, but we are not sure that any were seen. All the small fish which looked like trout proved upon examination to be young chinook salmon.

Temperatures recorded at camp on Alturas Lake Inlet, August 29 to September 18, 1895.

Date.	8 a. m.		12 m.		8 p. m.		Remarks.
	Air.	Water.	Air.	Water.	Air.	Water.	
	Degrees.	*Degrees.*	*Degrees.*	*Degrees.*	*Degrees.*	*Degrees.*	
Aug. 29	....	....	....	....	45	49	
30	47	43	65	49	45	50	Several thunder-showers last night.
31	47	42.5	74	49	48	51	
Sept. 1	38	42.5	70	48	46	49	
2	49	43	52	47	48	48.5	Taken at 9 p. m.; strong wind.
3	47	43.5	52	46	50	47	Light rain in morning; windy all day.
4	47	43	50	46	45	48.5	Taken at 8.45 p. m.
5	37	43	45.5	46	37	47	Rain; snow on mountains.
6	29.5	39.5	....	....	33	43	Taken at 9 p. m.; fair.
7	29	38.5	56	44	38	47	Fair.
8	36	39.5	64	46	50	48.5	Rain.
9	41.5	42.5	44.5	44.5	38	43	Snow and rain all day.
10	35.5	40.5	40	42	37	41.5	Taken at 1 p. m.; some snow; rain at night.
11	38	40	47	44	42	43.5	Taken at 1 p. m.; rain all last night and most of to-day.
12	45	42.5	52.5	44.5	66	55	Continuous rain.
13	45	43	46	44	36.5	43	Hard rain all day.
14	31	38.5	44	43.5	32	44	Clear and cold.
15	28	37.5	51	43.5	43	45	Do.
16	35	39	63	46	41	45	Clear and warmer.
17	32	39	58	44.5	45	47	Still clear.
18	39	41	[1] 76	[1] 57	[1] 47	[1] 57	Clear and warmer.
19	[1] 44.5	[1] 50	[1] 46.5	[1] 52	....	....	Cold rain all day.

[1] These temperatures were taken at the camp on the outlet of Alturas Lake.



PETTIT LAKE, IDAHO; ALTITUDE 7,300 FEET.

The two small inlets to this lake are visited by the Redfish or Blueback Salmon (*Oncorhynchus nerka*) for spawning purposes.

PERKINS LAKE.

This is a small lake situated about 300 yards below Alturas Lake, the outlet of Alturas Lake flowing through it. The greatest length is about one-fourth of a mile and the greatest width about one-eighth of a mile. The general direction, like that of Alturas and Pettit lakes, is northeast and southwest, or perhaps a little more nearly north and south. The shore line is quite regular. At the head of the lake, near the inlet, is a small peninsula extending into the lake; near the lower part of the east side is a considerable inward curve in the shore line, while the west shore is made up of small curves. The inlet is at the upper left-hand corner and the outlet is on the same side of the lower end.

The shores of this lake are everywhere low, rising only a few feet above the level of the lake's surface and extending back from the lake in all directions without much, if any, increase in elevation. A heavy growth of small Murray pines surrounds the lake; just above the lake is a small meadow, which has evidently been covered with water at one time, and it is even yet somewhat marshy; on the left the narrow strip of pines separates the lake from a large meadow, which extends to the mountain more than a mile to the westward. This meadow supports a good growth of the native grasses, with here and there large patches of gentians and castellejas.

About the upper end of the lake is considerable marshy ground, and the shores are muddy; elsewhere the shores are either of white sand or fine gravel.

Perkins Lake is quite shallow. Six lines of soundings were run, and the depths found are all indicated on the accompanying map. The greatest depth obtained was 25 feet, east of the point projecting into the lake at the upper end. Over the larger part of the lake the depth is pretty uniform, ranging from 19 to 25 feet. At the lower end it is shallow, not anywhere exceeding 9 feet, and usually not over 5 feet. At the upper end the bottom is somewhat muddy, particularly in the large basin toward the right; elsewhere the bottom is of fine gravel or clean white sand.

There is considerable aquatic vegetation, patches of *Myriophyllum*, *Potamogeton*, *Chara*, and perhaps other species, being found in various places. In the shallow water about the head of this lake and in the marshy areas connected with it the young of *Leuciscus balteatus* and *Catostomus machrocheilus* were found during August and September in great abundance, and with them were many young *Ptychocheilus oregonensis*, *Coregonus williamsoni*, and *Salmo mykiss*, these last three species becoming less abundant as the water became warmer. There were also a few *Rhinichthys cataractæ dulcis* and *Agosia umatilla*.

While this lake is small, it is nevertheless an important one in its relation to the fish life of the Upper Salmon River Valley. Its shallowness, extensive mud bottom, warmer water, and considerable vegetation, are apparently conditions favorable to the hatching and growth of the young of the above species, which must form an important part in the food supply of the trout and the young salmon and redfish.

Pettit Lake.—The next important lake of this group is generally known as Pettit Lake,[1] and is situated about 5 or 6 miles north from Alturas Lake. This lake is

[1] The nomenclature of the lakes in this region is still somewhat indefinite. The names given on the General Land Office map (1891) do not conform to local usage in a single case. On that map a good-sized lake is placed at the head of Beaver Creek and called Atlanta Lake. Mr. Perkins and Mr. F. C. Parks inform us that there is no lake there, and that there is no lake in the Sawtooth Mountains bearing that name. Alturas Lake is located, but no name is given it. The next lake of the series is Pettit Lake, the one called Redfish Lake on the map; while the ones called Pettit Lake and Goat Lake on the map are apparently meant for Redfish Lake and Stanley Lake.

smaller than Alturas Lake and is more irregular in outline. The greatest length is about 1.1 miles, while the greatest width is about half a mile. The upper half of the lake has the sides relatively parallel, but the lower half is quite irregular in outline. The outlet is at the lower left-hand corner; on the right of this is a considerable peninsula projecting into the lake. At its outer end it turns toward the right shore and has very much the shape of a fish-hook, inclosing a small shallow bay.

Like Alturas Lake, this lake is also of glacial origin and lies between two immense lateral moraines. The ridge on the right is apparently composed entirely of morainic material. At the upper end of the lake this ridge is 200 or 300 feet above the surface of the water, but it becomes gradually lower as it approaches the Salmon River Valley, until opposite the lower end of the lake it is perhaps not over 50 feet high.

The ridge bounding the lake on the north rises rather abruptly, attains a height of 500 or 600 feet, and probably possesses a granite axis or core. To the left, this ridge is continuous above with Mount Parks, and below, it extends far out into Salmon River Valley. The terminal moraine extending across the canyon at the foot of the lake has a broken, uneven surface, and the outlet through much of its course possesses many rapids. The ridge on the left and the upper end of the one on the right are covered with a heavy growth of conifers, chiefly Murray pine and Douglas fir. The Murray pine grows most abundantly near the lake and on the lower slopes, while the fir is rarely found on the lake shore, it being found chiefly somewhat above the lake. At the head of the lake is a narrow valley or canyon densely wooded throughout. Near the lake it is level and somewhat marshy in places and supports a heavy growth of Murray pine, Douglas fir, and white spruce.

Pettit Lake is quite deep. Lines of soundings were run across it in various directions and the depths found are indicated on the accompanying map. As will be noticed, this lake, like Alturas, has its greatest depth near the upper end and toward the left shore. That part of the lake reaches a maximum depth of 175 feet. The lower third of the lake is comparatively shallow, a greater depth than 23 feet not being found. The narrow bay at the lower end on the right side is still more shallow, 7½ feet being the greatest depth found.

At the head of the lake a fine sand bottom extends out until at least a depth of 40 feet is reached. There are also some areas of white sand bottom along the right side, but most of this portion is covered with small granite rocks. The lower half of the lake, particularly the narrow shallow bay, has a sand bottom except along the immediate shore, where it is usually rocky. The left shore of the lake is usually rocky and the bottom descends very abruptly, a depth of 50 feet or more being reached within a few feet of shore.

There seems to be less vegetation in this than in Alturas Lake. Small patches were observed at various places in relatively shallow water, but we did not determine the character of the bottom in the deeper places, so do not know whether there is any vegetation there. The water is very clear and pure. Where the bottom is of white sand it can be clearly seen at a depth of 40 feet, but in the deep parts of the lake the water appears very dark when viewed from the boat.

Temperature.—The water of this lake is very cold. Surface temperatures were taken at irregular intervals from July 26 to August 12, after which the temperature of the surface near our camp was taken regularly three times daily. The results are set forth in the tabular statements which follow. The bottom temperature in the deeper

parts was found to be from 4° to 10° colder during the day than the surface temperature taken at the same time. The maximum difference was found at noon, July 29, when the surface was 68° and the bottom, at 165 feet, 58°. This is probably as great a difference as existed at any time, even in the warmest weather. The nights were always quite cold enough to reduce the temperature of the surface water to that of the bottom or even below it, and not until some time after sunrise would it again exceed the bottom temperature.

Temperatures taken in Pettit Lake and connecting streams in July and August, 1895.

Date.	South inlet.	North inlet.	Lake.			Outlet.
			Surface.	Bottom.	Air.	
July 26	52°, noon	53°, 12.30 p. m.	63°, 1 p. m.	59°, 1 p. m.		
29	48½°, 11 a. m.	52°, 11 a. m.	68°, noon	58°, at 165 feet, noon		
30		50°, 10 a. m.	65°, 9.30 a. m.	60°, at 70 feet, 9.30 a. m.		
Aug. 1	51°, noon	53°, noon	64°, 10 a. m.			
2	47½°, 9.30 a. m.	50°, 9 a. m.	63°, 9.15 a. m.			
6	48°, 10.30 a. m.	51°, 10.15 a. m.				
8			61°, 8 a. m.			
9			63°, 9 a. m.		36°, 8 a. m.	
11	46°, 11.45 a. m.	50°, 12.15 p. m.			80°, 5.17 p. m.	
13	49°, 10.45 a. m.	49°, 10.45 a. m.				
14						61°, 9.15 a. m.
17						71°, 3.50 p. m.
22	47°, 9 a. m.	47°, 9 a. m.				67°, 2 30 p. m.
23	47°, 10 a. m.	48°, 10 a. m.				
25	47°, 8.45 a. m.	47½°, 8.45 a. m.				61°, 6.15 p. m.
26	44°, 10.10 a. m.	48°, 10.30 a. m.	62°, 11.15 a. m.			63½°, 11.30 a. m.
27	45°, 12.30 p. m.	47°, 11.30 a. m.				57°, 10 a. m,

[1] Temperatures recorded in this paper are in Fahrenheit degrees and taken with the Wilder protected thermometer.

Temperatures taken at camp on Pettit Lake, August 12 to 28, 1895.

Date.	8 a. m.		12 m.		8 p. m.		Remarks.
	Air.	Water.	Air.	Water.	Air.	Water.	
	Degrees.	*Degrees.*	*Degrees.*	*Degrees.*	*Degrees.*	*Degrees.*	
Aug. 12	50	61	67½	65			Beginning with August 12, the temperature of both air and water was taken at 8 a. m., noon, and 8 p. m. The place selected for taking that of the water was near our camp, which is indicated on the map, and in water 1 to 2 feet deep, the thermometer being allowed to rest upon the bottom. The thermometer for air temperature was kept on the shaded side of a small cabin on the lake shore at our camp.
13	54		72		65	65	
14	46	61	78	66½	67	66	
15	53	61½	74	65½	66	66	
16	48	61	67½	65	59	65	
17	48	61	71	64	63	65½	
18	48	62	72	65	62	65	
19	51	61½	76	66	64	66	
20	50	61	73	65	52	65	
21	51	63	64	63	58	64	
22	48	61	66	64	59	64	
23	48	60	65	64½			
24			67	65	55	63	
25	50	60	67	64	54	64	
26	46	61	62	63	53	61½	
27	44	59	54	61	47	61	
28	42	59					

Pettit Lake does not differ materially from Alturas Lake in the animal and plant life which it supports. So far as we were able to learn, the fishes of the two lakes are identical as to species, *Rhinichthys*, *Cottus*, and *Agosia* being apparently more common in Pettit, while suckers seemed to be more abundant in Alturas Lake.

Inlets.—This lake has two inlets, both of which enter it at the upper end, as shown on the accompanying map. The inlet to the right is much smaller than the other, and is probably not over 1½ or 2 miles long. The other is at least 5 miles in length. The canyon through which these streams flow is extremely rough and rocky, except near the lake, where it is level and somewhat marshy. But beginning a mile or so above the lake there is scarcely any soil in many places, the bedrock coming to the surface in a wonderful series of mutton-backs, many of which are of immense size and show the largest grooves and most interesting striations I have ever seen. There are in places great masses of fallen timber, which have been brought into the canyon by frequent snowslides, while in other places are large quantities of rock fragments, which have been brought down by snowslides or which have fallen from the cliffs above.

The right side of this canyon is for the most part rather steep, but pretty well timbered, while on the left it is bounded by a great granite wall, in some places perpendicular for several hundred feet. There are occasional breaks in this wall, but it is difficult to find any place where one can climb to the top from below. In descending into this canyon from the summit of Mount Parks, we were compelled to go several miles above the lake before finding a place where we could descend this wall. Between the top of the wall and the summit of the mountain is a large area covered with slide-rock, which every year contributes liberally to the *talus* at the foot of the wall. This mountain peak, named Mount Parks, is the culmination of the ridge separating Pettit Lake from Yellowbelly Lake, and is 10,400 feet above sea level. It is an extremely rugged peak extending about 1,000 feet above timber line. In the more protected places on its slopes the snow remains continuously.

At the head of the main inlet to Pettit Lake are two small lakes, the larger known as Alice Lake. Their outlet has numerous falls and cascades. These lakes apparently have no fish in them.

Redfish Lake.—This is the largest of all the so-called redfish lakes, and is situated on the west side of Salmon River Valley, about 15 miles below or north of Pettit Lake. It is about 6 miles long and a mile wide, and, like all the other lakes of this series, its general direction is northeast and southwest. There are no large irregularities in the shore line, but the middle of the lake bows somewhat to the east. The right shore is low in most of its extent, rising gradually into a high morainic ridge, 200 to 400 feet higher than the lake. The left shore is abrupt and rocky throughout most of its length, and ascends rapidly into a high, rugged mountain ridge.

At the head of the lake the shore is also rocky, and ascends into precipitous cliffs, there being no level valley above. There are here two small inlets and one considerably larger. They all have their rise in the snow-fields lying among the extremely rugged mountains which lie beyond the lake. The canyons down which they come are remarkably rough, being filled with *roches moutonnées*, loose bowlders, fallen and tangled timber, and other obstructions. The largest of these inlets enters the lake near the left or west side of the upper end, and is about 25 feet wide and 2 feet deep near the mouth. It would be very difficult for fish to ascend this stream more than a few hundred yards, so full is it of fallen timber, rapids, and cascades; indeed, it seems that wholly impassable falls would soon be encountered.

At the lower end of the lake, toward the left shore, another important inlet is received. This stream has its rise in several forks among the high mountains at the head of the lake, and flows down a narrow canyon nearly parallel with and only a short distance from the left shore of the lake. Near its lower end it makes a somewhat abrupt turn to the right and enters the lake only a few rods from the outlet. This creek is the longest of the inlets, and probably carries as much water as all of the others. It has its sources in the permanent snow-fields, among the ragged, beetling crags about the head of this lake, probably the most rugged and inaccessible of all the peaks of the Sawtooth Range.

At or near the heads of these inlets are several small lakes, all very cold, and most of them apparently quite deep. One of the most beautiful and most interesting is at the head of the left branch of the lower inlet. Its altitude is about 9,500 feet, and its area perhaps 10 acres. Its shores on all sides are of bed rock, and very steep. The lake occupies a circular depression in the rock, the origin of which is not easy to explain. At the outlet the water flows over a narrow ledge of rock *in situ*, and at all other places the shores are of rock, in places rising from 10 to 400 feet above the lake. There has been no damming by moraines, and the great depth of the basin and the character of the shores preclude the belief that it is of glacial origin, except upon the supposition that the descent of the glacier was very abrupt and that its force was exerted as a gouging agent, deepening the hole at the foot of the peak without wearing away the rock below.

On the right side is a snow-field of considerable size, whose base is laved by the waters of the lake and which reaches up among the inaccessible spires which tower several hundred feet above. This lake is quite deep, as is shown by the dark, blue color of the water, and the descent is very abrupt; nowhere, except at the outlet, is there room for one to walk along the water's edge. The outlet of this lake has numerous falls and cascades, and can not be ascended by fish.

The immediate shores of Redfish Lake and the immense morainic ridges lying on either side of it are covered with a heavy growth of Murray pine and Douglas fir.

Depth.—Redfish Lake is the deepest of this group of lakes which we sounded. We were not able in the time at our command to run systematic lines of soundings across the lake. Several soundings were made in the upper end, and depths ranging from 100 to 296 feet were found. The greatest depth, 296 feet, was obtained near the left shore and not far from the upper end of the lake. The lower portion of the lake is somewhat shallower.

Temperature.—This lake is apparently colder than Alturas or Pettit Lake. On August 21, readings of the surface temperature were taken at various times and at several different places, and 61° was the uniform result obtained. That of the main upper inlet at its mouth was 44°; that of the lower inlet was the same.

The fishes of this lake are, so far as known, the same as those of Alturas and Pettit lakes. The large redfish are known to come to this lake, but none came in 1895, so far as we were able to learn.

The outlet of Redfish Lake is quite a stream, carrying perhaps twice as much water as is discharged by Alturas Lake. It is broad, with a rocky bed, and flows through a relatively level and a narrow valley. A short distance below the lake it flows through a small, unnamed lake, in the same manner as the outlet of Alturas Lake

flows through Perkins Lake. The lower part of Redfish Lake outlet was not examined by us; nor were we able to make any examination of Stanley Lake, the last one of the series of Redfish Lakes.

THE UPPER SALMON RIVER AND ITS TRIBUTARY STREAMS.

In its upper course the Salmon River occupies a broad, treeless valley, whose elevation is from 7,000 to 7,300 feet above sea level. Except along the immediate banks of the river and its tributary streams, and in certain marshy places, the valley is well covered with sage (*Artemisia tridentata*). Along the streams are more or less dense thickets of willows (*Salix rostrata*), and in the marshy areas are grasses, gentians, and a white marsh marigold.

The general direction of the valley from its head to opposite Redfish Lake is nearly due north and south. The river is very tortuous in its course, but below the mouth of Alturas Creek it keeps chiefly to the west side of the valley.

The hills and ridges on the east side of the valley are either wholly without forests or have only isolated clumps of trees here and there, and narrow fringes of trees along the small creeks which come into the valley from that side. On the west there is heavy forest everywhere, even upon the long, narrow morainic ridges which extend out into the valley, forming such a marked and characteristic feature of the landscape.

Above the mouth of Alturas Creek, Salmon River receives several small tributaries, the principal ones being Washington, Smiley, and Beaver creeks from the left, and Pole, Lost, and Warm Spring creeks from the right. Of those from the left, Beaver Creek is the most important. It has its rise on the divide beyond Shaw Mountain, and flows northeast. The town of Sawtooth is situated upon this creek.

All of these creeks are said to be excellent trout streams.

Alturas Creek.—This is the most important stream tributary to the upper Salmon River. It is not only the outlet of Alturas and Perkins lakes, but it receives, also, the outlets of Pettit and Yellowbelly lakes. The general direction of Alturas Creek (or Lake Creek, as it is frequently called) is north, and its length is about 4 or 5 miles. Its average width is 40 to 60 feet, and in August the depth ranges from 1 foot to 4 or 5 feet. In its upper course it is relatively broad and quite uniformly shallow, with a moderately swift current over an even bed of small gravel. Here and there large glacial bowlders are seen in the stream. After passing through Perkins Lake, the stream widens somewhat for a short distance, then becomes narrower and more swift and the banks become less uniform in height; in some places they are 3 or 4 feet high, in others low and marshy. The shores are well timbered with Murray pine throughout the course except in the last 1½ or 2 miles, or along that portion lying within the Salmon River Valley proper. There they are covered with sage on the dry portions and willows and an occasional alder where the ground is marshy. The special importance of this stream lies in the fact that the chinook salmon have spawning-beds in its lower course.

Alturas Creek receives three tributary streams from the west, viz, Meadow, Pettit, and Yellowbelly creeks. The first of these is a very small, cold creek, fed almost entirely by springs, and has its head on the mountain ridge separating Alturas and Pettit lakes.

Pettit Creek, the outlet of Pettit Lake, is about one-third the size of Alturas Creek, and is between 1 and 2 miles long. Immediately below the lake the outlet is broad and bordered by marshy ground, but soon it becomes a narrow stream filled with large rocks and possessing a swift current. At several places are considerable obstructions caused by fallen timber which has collected in the stream and which would seem to interfere with the free movements of fishes.

The outlet of Yellowbelly Lake is a similar but smaller stream, which joins Alturas Creek a short distance below the mouth of Pettit Creek.

The creeks which unite with Salmon River below the mouth of Alturas Creek are Roaring Creek on the west and Champion and Fourth of July creeks on the east. We made no special examination of these creeks. It is said that there are few, if any, fish in Roaring Creek, while the headwaters of the other two are said to furnish excellent trout-fishing. The Salmon River, in this part of its course, is a stream of considerable size, 40 to 100 feet wide, and with a very swift current in most places. There are long reaches where the water, 2 to 3 feet in depth, flows rapidly over a bed of clean, coarse gravel; in other places the width is somewhat greater, the depth a little less, the current correspondingly slower, and the bed of finer gravel and sand. At the foot of each of these shallow reaches is usually a quiet pool from 4 to 10 feet deep, in which the larger cut-throat trout and the bull trout delight to loiter.

BIG PAYETTE LAKE AND VICINITY.

Big Payette Lake is the principal lake of the Payette group, situated at the headwaters of the North Fork of Payette River. Mr. T. M. Williams carried on observations here from July 19 to September 25, 1895. He reports the lake as being quite irregular in shape. The main body is 6 to 6½ miles in length from north to south, and about 2 miles wide. At the north end is a long narrow arm extending to the southeast a distance of at least 5 miles; just below the inlet the main arm is greatly constricted, the width there being only a few rods, several rocky islets being found here. A large number of soundings was taken, and the depth in the lower or main portion was found to vary from 40 to 260 feet, the average depth being perhaps as much as 200 feet. The depths found in the arm vary from 130 to 305 feet, the average being about 200 feet. The maximum depth, 305 feet, was found near where the arm joins the main body, or a little southeast from the inlet.

The temperatures taken at this lake are given in the table on page 169.

Payette River.—This river was examined as far down as Van Wick, 40 miles below the lake. Throughout this distance it runs through a large valley known as Long Valley. The fall is not great, there being but one rapids in this distance. The river bed is composed chiefly of gravel and sand, and affords ideal spawning-grounds for salmon. It is only in the upper 10 miles of the stream, however, that spawning-grounds are known. Along this river are a great many small swamps, caused in most instances by old beaver-dams. The only tributaries of importance to this portion of Payette River are Lake Fork, Gold Fork, and Bowlder Creek, all of which come in from the east side and join the main stream near the same point. Lake Fork joins the river about 20 miles below Big Payette Lake; a short distance below comes in Bowlder Creek, a much smaller stream, and a little farther down is Gold Fork, which is about the size of Lake Fork.

Gold Fork and Bowlder Creek are said to have been favorite spawning streams for the chinook salmon years ago, but now both of those streams are pretty well filled up with the washings from the gold mines in the mountains above. But few salmon enter them now, and it is said these spawn rather earlier than do those which spawn in the main river.

Lake Fork has never been noted as a salmon stream. This is probably due partly to the fact that it is a much rougher stream with more rocky bed. The last 20 miles of its course is nearly parallel with that of Payette River.

Little Payette Lake, which is drained by Lake Fork and which is about 20 miles above its mouth, is only a mile from Big Payette Lake, but its altitude is about 100 feet greater. This lake is a small one, its greatest length being not more than three-fourths of a mile. It is comparatively shallow and has a good many water plants growing in and around it. It is bordered by a considerable swamp, which probably indicates that the lake was formerly larger than it now is. A few miles above Little Payette Lake its inlet passes through a very narrow and deep canyon where the current is swift and turbulent, and fish would experience some difficulty in making the ascent. Above this place are several small tributary streams which are said to be well filled with native trout.

Payette River above Big Payette Lake is quite deep for the last 2 miles of its course and the current is slow. Between 3 and 5 miles above the lake is the part of the stream in which are located the spawning-beds of the redfish. The stream here is made up of long reaches with a depth of 1 to 4 feet, a moderately swift current, and a bottom of clean fine gravel and sand, connecting deeper holes where the current is slower and the bottom of sand alone. About 9 or 10 miles above Big Payette Lake is Upper Payette Lake. This is about a mile long, one-fourth of a mile wide, and is said to be quite deep. The redfish are said not to ascend to this lake, but trout are very abundant in it.

In the rugged mountains east of Big Payette Lake are several small lakes, a few of which were visited by Mr. Williams. One of these is known as Loni Lake, situated near the summit of the mountains, and 3,000 or 4,000 feet above and 15 miles east of Big Payette Lake. It is at the head of one of the branches of Bowlder Creek, and is triangular in shape, each side measuring about half a mile. The shores are steep and rocky, being composed in many places of bowlders. The outlet at this season (September) is underground, passing through the loose bowlders. The fall of the outlet is very precipitous for several hundred feet, and fish can not now ascend to the lake, which is fed by springs and the melting snows from the surrounding mountains. The greatest depth found by Mr. Williams in this lake was 60 feet. The surface temperature of the water was 54.5°, September 18, when that of the air was 61°.

Bowlder Lake is another small lake found here. It lies a few miles north of Loni Lake, and is about three-fourths of a mile long by one-fourth of a mile wide. It appears quite deep, but no soundings could be taken. It is at the head of Bowlder Creek, and is fed by numerous small cold springs. It is held in place by a ledge of hard sandstone extending across its outlet, which has much the appearance of an immense stone dam. If this lake is of glacial origin, as one would suppose, it has been gouged out rather than formed in the ordinary way in which glaciers act. In this respect it resembles the small lake, at the head of Redfish Lake, described on page 165.

The outlet is quite steep for some distance, and fish can not ascend to the lake. The temperature of the lake at the surface was 50° at noon, September 19, when the air was 38°.

The following is a list of temperatures taken from the shore of Big Payette Lake about a mile east of the outlet. The lake at this point is shallow for probably 150 feet out from shore, where the bottom breaks off precipitously. Near the shore there is a scanty growth of various sorts of water vegetation. The water probably varies more in temperature at this point than it does at the surface in the deep portion of the lake.

Temperatures taken at Big Payette Lake in 1895.

Date.	Hour.	Air.	Water.	Date.	Hour.	Air.	Water.
		° F.	° F.			° F.	° F.
[1]July 20	8.30 a. m	58	63½	Sept. 1	6.30 a. m	44½	60
20	6 p. m	64	68	1	2 p. m	68½	66½
21	8 a. m	65	65	1	6 p. m	68½	65
21	6 p. m	75	70	2	6 a. m	43	59
22	7.30 a. m	57	65	2	12 m	58½	62
22	7.30 p. m	70	67	2	6 p. m	57	59½
Aug. 15	do	64	67½	[5]3	6 a. m	46	57½
16	8 a. m	55	65	3	7 p. m	54	59½
16	12 m	77½	69	4	6 a. m	46½	58
17	7.30 p. m	57½	67	4	6.30 p. m	....	57
18	6.30 a. m	44½	62	[6]5	7.30 a. m	42½	56½
18	3 p. m	80	69	[7]6	7 a. m	28	54
18	8 p. m	64	68	6	12 m	53	63½
19	8 a. m	65	64½	6	6 p. m	43	61
19	1 p. m	79	70	7	7 a. m	29	54
20	7 a. m	56	65	7	12 m	61	61½
20	1 p. m	75	69	[8]8	8 a. m	50	56½
20	6.30 p. m	69½	67	9	7 a. m	45	55
[2]21	6.30 a. m	53	64	[9]10	6 p. m	43	60
21	12 m	68	66	11	7 a. m	39½	54½
23	7 a. m	50½	65	11	12 m	46½	60
23	1 p. m	71½	72½	11	6 p. m	47½	55
[3]25	6 a. m	57½	63½	12	7 a. m	55	49
25	1 p. m	72½	71½	13	6.30 a. m	47½	60
25	6.30 p. m	59½	66	13	12 m	54½	43
26	9 a. m	57½	62	13	6.30 p. m	43	55
26	12 m	68	63½	[7]14	6.30 a. m	32	53
26	6 p. m	48	59½	14	6 p. m	37	57
27	7 a. m	50	58	[10]15	7 a. m	32	53
27	12 m	64½	68½	15	12 m	58	59
[4]28	6.30 a. m	57½	60	16	6 a. m	32	53
28	6.30 p. m	59	63½	16	3 p. m	61	54½
29	6 a. m	41½	58½	[11]23	7 a. m	40	51

[1] Day and night before cold and windy.

[2] Rain and wind during night before.

[3] Windstorm in afternoon; strong wind from northwest during night; cold northwest wind.

[4] Thunderstorm in afternoon.

[5] Cold south wind all day.

[6] Rain storm during night.

[7] Cold, clear, and frosty.

[8] Rain and windstorm from southwest during night.

[9] Continued rain from September 10 to 14.

[10] Clear and cold.

[11] Cold and clear for several days previous.

The following temperatures were taken at irregular hours from various streams and lakes in the vicinity of Big Payette Lake:

T peratures of various streams about Big Payette Lake recorded by Mr. Williams in 1895.

Date	Hour.	Air.	Water.	Place.
		° F.	° F.	
July 28	7 a. m	63	67	Payette River, 40 miles below lake, at Van Wick.
Aug. 16	12 m	77½	68½	At outlet of lake.
16	7 p. m	62½	69½	2 miles below lake.
17	6 a. m	34	56½	Do.
17	12.30 p. m	75	66½	5 miles below lake.
17	4 p. m	75	68	10 miles below lake.
18	6.30 a. m	44½	65	At outlet of lake.
21	7 p. m	63	65	At inlet of lake.
22	7.30 a. m	53	63½	Do.
22	3 p. m	68½	66	Do.
22	6 p. m	64	65	Do.
23	7 p. m	61	66	Do.
24	6 a. m	46	63	Do.
24			48½	Small stream 1½ miles above lake.
24			44½	Small stream 2 miles above lake.
24	10 a. m		54	Redfish spawning-grounds, 3 miles above lake.
24	12 m		61½	River 1 mile above l ke.
24	6 p. m	62½	66½	At inlet of lake.
28	12 m	60	62½	7 miles below lake.
29	11 a. m	70	43	Small spring, tributary to lake on east side.
29	12 m	70	68	Little Payette Lake.
29	1 p. m		50	Small stream, tributary to Little Payette Lake.
29			48	Small streams near top of mountain, north of the Payette lakes and tributary to those lakes.
30			48	
30			43	
30			52	
30	6 a. m	46		
30	2.30 p. m		56½	Lake Fork, 6 miles above Little Lake.
30	3 p. m		53½	East prong of Lake Fork, 7 miles above lake.
30	5 p. m		60	North prong of Lake Fork, 8 miles above lake.
31	6 a. m	41	47	Lake Fork, 6 miles above Little Lake.
31			51	Small streams, tributary to Lake Fork, a few miles above lake.
31			52	
Sept. 3	12 m		51½	Payette River, 4 miles above lake on redfish spawning-grounds.
3	do		51½	In pool with redfish.
3	2 p. m	58	58	At inlet of Big Lake.
3	Between 2 and 4 p. m.	[1]60	43	Small streams, tributaries of Big Payette Lake from west side, beginning at the north.
3		[1]60	43	
3		[1]60	47	
3		[1]60	43½	
3			48½	
3			49	
4			50	In pool with redfish, 4 miles above lake.
16	12 m		55	Payette River, 8 miles below lake.
17	do		58	Lake Fork, 3 miles below Little Lake.
17	2 p. m		46½	Boulder Creek, 15 miles from junction with Payette River.
18	8 a. m	38	38	Spring near top of mountain south of Boulder Lake and a tributary of Gold Fork.

[1] About.

DETAILED REPORT UPON THE SALMON AND OTHER FISHES OBSERVED.

In the following pages is given a list of all the fishes observed in those portions of Idaho covered by this report, together with detailed natural-history and technical notes upon each. The notes on the quinnat salmon and redfish are made particularly complete, in the thought that any fact contributing to an understanding of the life-histories of these important food-fishes will prove of interest and value.

1. Entosphenus tridentatus (Gairdner). *Three-toothed Lamprey.*

This lamprey was found in abundance August 8, 1893, by Dr. Gilbert at Lower Salmon Falls. More than 40 examples were seen, all of them dead. While at these falls in September and October, 1894, I was told that it is very common there during late summer and early fall. I saw none during my stay, although special search was made October 7 along the foot of Lower Salmon Falls. It was also reported as common at Glenn Ferry and at Weiser. At these places I heard it spoken of as being good sturgeon bait. On September 26, 1894, while examining the inlet of Payette Lake, I found one dead individual about 3 miles above the lake. Among the specimens sent in by Mr. Williams is one of this species obtained August 11 in Payette River a mile below the lake. It was found dead, and measures 2 feet in length. The distance between the dorsal fins is about one-third the length of the first dorsal. The length of the head is contained 11 times in total length.

2. Acipenser transmontanus (Gairdner). *Columbia River Sturgeon.*

This immense sturgeon is not uncommon in Snake River as far up as Lower Salmon Falls, and is occasionally taken at Millet Island just below Upper Salmon Falls. At the Lower Falls it is said to have been more common in 1893 than in 1894. Mr. Charles Harvey, who lives near the Lower Falls, says he caught 3, each of about 15 pounds weight, in March, 1894. In September and October several others were taken at the same place, some of them weighing 100 pounds or more each. Mr. Harvey says he has seen them 8 or 9 feet in length, and Mr. Bliss reports one 11 feet 5 inches long. Another weighing 700 pounds is reported to have been caught at these falls. On September 1 Mr. Barnum saw one at these falls which was about 4 feet long.

Mr. Liberty Millet has caught sturgeon at Millet Island, and says that the best fishing begins just after high water and continues until the salmon arrive. They are usually taken on set lines about 300 feet long, having 8 to 10 hooks. The largest sturgeon he ever saw was 11 feet 2 inches long, probably the same one seen by Mr. Bliss. It measured 2 feet across the head. One 35 inches long and weighing 7½ pounds was seined by Mr. Millet, October 5. He has seen them only 1½ feet long. He also says he has caught them when their spawn was ripe and believes they spawn at any time.

Glenn Ferry, on Snake River, is said to be a good place for sturgeon. We saw 2 small ones, one a foot long and the other weighing 4 pounds dressed, when there in September, 1894. One taken a few days earlier weighed 60 pounds, and some weighing 800 to 1,000 pounds, are reported.

Mr. William O'Brien, who has a fishery on Snake River about 4 miles below Weiser, does some sturgeon fishing; says he has caught them weighing 600 to 650 pounds; the largest one he ever saw was 13 feet long; once he caught 2 in his seine, each measuring 11 feet in length; never noticed any with ripe spawn; has seen suckers at least a foot long in their stomachs; has also found salmon heads, viscera, etc., in their stomachs. Lampreys make excellent sturgeon bait. Sturgeon are most plentiful in the spring and when the water is muddy. While we were at Mr. O'Brien's fishery September 22 and 23, 1894, a few small sturgeon were taken in the salmon seine. One example, a male 25 inches long, had 11 minnows in its stomach, all of which appeared to be *Mylocheilus caurinus*. Another male, 31 inches long, had the stomach nearly empty, there being nothing that could be identified.

The smallest examples of this sturgeon that I have seen are 6 and 7 inches long respectively, and were taken by Mr. O'Brien September 28, 1894. The number of plates on each of these and on 2 others from the same place is shown in the following table:

Length of specimen.	Number of dorsal plates.	Number of lateral plates.	Number of ventral plates.
Inches.			
6	10	41 and 41	9 and 9
7	14	40 and 41	10 and 10
25	12	45 and 47	10 and 12
35	13	47 and 50	

The lateral and ventral plates are not particularly strong, but those of the dorsal are very large and strong, the height being one-fourth inch in the highest.

3. Pantosteus jordani Evermann. "*Black Sucker*"; "*Blue Sucker*."

I saw several examples of this sucker at Glenn Ferry, which were caught in Mr. Henry Olsen's seine September 19, 1894. Others were seen at O'Brien's fishery, below Weiser, but it was not seen at Millet's nor elsewhere on Snake River. This species had previously been taken by us in the Columbia River Basin at the following places: Snake River at Idaho Falls, Ross Fork near Pocatello, Boise River at Caldwell, Payette River at Payette, Umatilla River at Pendleton, Columbia River at Umatilla, and Natchess River near North Yakima.[1] It has also been taken by Dr. Eigenmann[2] in the Boise River at Caldwell. It was not found by us at the Redfish Lakes, but the collections made by Mr. Williams at Big Payette Lake indicate that it is not an uncommon fish in that region. His collections contain numerous specimens from Payette River 4 miles above Big Payette Lake, and from Big Payette Lake itself.

In the following table are given comparative measurements of 9 of these specimens. Nos. 40 and 41 are from Snake River at Glenn Ferry, the others from Big Payette Lake and vicinity:

No.	Length.	Sex.	Head.	Depth.	Snout.	Eye.	Dorsal.	Anal.	Scales.
40	13	Male.	5	5	$2\frac{1}{5}$	$6\frac{1}{2}$	11	7	15– 91–13
41	12	Male.	5	5	$2\frac{1}{5}$	$5\frac{3}{4}$	12	7	16–100–15
197	$11\frac{1}{4}$	....	$5\frac{1}{3}$	$5\frac{1}{5}$	2	7	12	7	17–103–15
198	$11\frac{3}{4}$	....	$5\frac{1}{4}$	$5\frac{1}{4}$	2	$6\frac{2}{3}$	12	7	16–103–13
199	$12\frac{3}{4}$	....	$5\frac{1}{3}$	$5\frac{1}{3}$	2	6	12	7	17– 99–15
170	$10\frac{3}{4}$	....	5	5	2	6	12	7	17– 94–15
171	12	....	5	$5\frac{1}{2}$	2	6	12	7	17–107–15
208	6	....	5	$4\frac{4}{5}$	$2\frac{1}{3}$	5	12	7	17–101–15

It will be noticed that these specimens are much larger than any of this species heretofore obtained. An examination of over 500 specimens collected in the Upper Missouri Basin in 1891, 1892, and 1893, and in the Columbia Basin in 1893, failed to discover any examples over 10 inches long. The posterior chamber of the air bladder is very long and slender, and renewed examination of that organ in this species and in several species of *Catostomus* confirms the view already stated by me, that the air bladder affords the best differential character upon which to separate *Catostomus* and *Pantosteus*.[3] The color of the peritoneum is also a character of value in determining these species; in *P. jordani* it is usually quite black, while in numerous examples of *C. catostomus* examined it is more or less silvery.

4. Catostomus macrocheilus Girard. "*Columbia River Sucker*"; "*Yellow Sucker*."

Abundant in all suitable places in the Columbia basin below the Auger Falls of Snake River. In 1894 I found it common in Snake River at Upper Salmon Falls, Glenn Ferry, and Weiser, and numerous young were taken in Mann Creek and in the small branch of Little Weiser River at Snow's. Mr. Williams found it in large numbers in Payette Lake and its outlet. In Alturas, Pettit, and Redfish lakes and their connecting streams it is one of the most abundant species. When Dr. Meek and Mr. Scofield began their observations, July 17, the suckers were found in the streams, but as the season advanced and the water became lower and less cold, they ran into the lakes, where they remained. After August 10 few adult individuals were seen anywhere except in the lakes, though the young, one-half to 2 inches long, were abundant in shallow, quiet water along the streams.

The gill net set in Alturas Outlet took a good many suckers at various times between July 20 and September 12. The catch was as follows: July 20th, 4; 22d, 1; 23d, 2; 24th, 3; 25th, 3; September 4th, 7; 6th, 1; 11th, 5.

During August and September suckers could be seen in large numbers at certain places in the lakes, the best place being about the mouth of the inlet. I first noticed them in Redfish Lake, August

[1] Gilbert & Evermann: Report upon Physical and Natural History Investigations in the Columbia River Basin, in Bull. U. S. Fish Comm., XIV, for 1894, 169–207.

[2] American Naturalist, Feb., 1893, and Bull. U. S. Fish Comm., XIV, for 1894, 107.

[3] Bull. U. S. Fish Comm., XII, for 1892, 52.

20 to 24. Upon going out in the lake about the mouth of the lower inlet in the evening between 5 and 8 o'clock, large schools of fish were seen swimming about at various depths in water 10 to 30 feet deep. After some little observation they were seen to be suckers and squawfish. Sometimes the two species would be mixed and in the same school, but usually they schooled separately.

The suckers ordinarily kept near the bottom while I observed them at this lake, but the large schools which I afterwards saw in Alturas Lake behaved quite differently. Large schools of fish were seen by Messrs. Meek and Scofield at various times in Pettit Lake, chiefly about the inlet or outlet, which were probably suckers or squawfish. Such schools were noticed August 14 and 19 and at other times. Between 7 and 8 o'clock on the evening of September 1 our most interesting observations on this sucker were made. What appeared to be a large school of fish was seen out in Alturas Lake, off the mouth of the inlet, swimming at or near the surface. Upon taking the boat and going out near them, we saw a large school of fish swimming about at the surface, many of them with their noses out of the water. Occasionally one would jump out of the water, and the entire fish could be seen. When they came within 5 to 15 feet of the boat they would take fright, and, with a quick flirt and splash, the entire school would descend beneath the surface, where they could be seen swimming along at various depths. Soon, however, they would ascend to the surface again and repeat the movements first noticed. The noses of many could be seen sticking above the water, and the disturbed surface resembled the ripple caused by the current of a creek flowing out and meeting the still water of the lakes. The schools were composed of 25 to 150 fish each. The majority appeared to be about a foot in length, though many were evidently much larger. We at first took them to be redfish; and in the glow of the setting sun and evening twilight they certainly appeared as red as any redfish we had ever seen. It was therefore with considerable surprise that we discovered, upon closer observation, that the belly and anal fin of each were *white*, and that each had a sucker mouth. We tried, without success, to gaff some of them, but afterwards we caught many of them in our seine and proved them to be *Catostomus macrocheilus*. They were observed at other times. At almost any time of day, when the water was smooth, they could be seen at various depths about the mouth of the inlet; but we never saw them swimming at the surface or jumping except in the evening and when the water was not disturbed by the wind.

This habit of swimming at the surface with the nose out of the water as if to get air, and the occasional jumping, has not, so far as I am aware, been hitherto observed or recorded in any species of *Catostomus*. It is not easy to determine what may be the purpose or meaning of this curious habit. It is not probable that it is for the purpose of obtaining air. In a lake of the size and depth of Alturas Lake, whose water is pure and cold and more or less disturbed every day by stiff breezes, there would seem to be no necessity of that kind. And it is even more improbable that they come to the surface for food. We observed them on several different occasions and at different times of the day, but at the surface only in the evening. The peculiar red appearance was most marked late in the evening.

Schools of fish seen by Dr. Meek in Pettit Lake, and at first thought by him to be redfish, he is now sure were suckers. I am convinced that the large schools which Mr. Comstock saw in Redfish Lake and thought to be redfish were really suckers; and it is quite likely that the "acres of redfish" which various persons have reported to have seen in these lakes were not redfish at all, but only suckers.

A great many suckers were caught at different times, either with the seine in the lake about the mouth of Alturas Inlet or in Alturas Outlet in the gill net. Comparative measurements of 57 of these are given in the accompanying table. Nos. 1 to 40, inclusive, were taken in the seine (39 of them at one haul) in Alturas Lake at the inlet, September 10. The smallest weighed three-fourths of a pound, the largest $1\frac{1}{2}$ pounds, and the total weight of the 40 fish was 44 pounds. Nos. 41 to 45, 248, and 249 were taken in the Alturas Outlet gill net September 4. They weighed two-fifths, two-fifths, one-fourth, one-fourth, one-fourth, one-fourth, and one-fourth pound, respectively. No. 42*a* is from Snake River at Glenn Ferry; Nos. 168, 169, and 172 from Payette Inlet; the others from Alturas Lake or its outlet.

In many specimens examined, the lower lip is incised nearly to the base, there being usually only one or two rows of papillæ, or sometimes none, across the base. The lobes are moderately long and rounded. The anal fin is high and pointed, its height being contained $1\frac{1}{3}$ to $1\frac{1}{5}$ in the head. In life these fishes were usually quite dark on back and sides down to axis of body, where the color changes abruptly to white, the contrast being very noticeable, even in the water. The anal fin is plain white. A large, broad tapeworm was frequently found in the abdominal cavity of these suckers.

Table of comparative measurements of 57 examples of Catostomus macrocheilus from Idaho.

No.	Length.	Sex.	Head.	Depth.	Snout.	Eye.	Dorsal.	Anal.	Scales.
1	$15\frac{1}{2}$	Female ...	$4\frac{1}{4}$	$4\frac{3}{4}$	$2\frac{1}{10}$	$6\frac{2}{3}$	13	7	13–72–11
2	16	Female ...	4	$4\frac{3}{4}$	2	6	13	7	13–66–10
3	14	Male......	$4\frac{1}{4}$	$4\frac{3}{5}$	$2\frac{1}{10}$	$5\frac{3}{4}$	13	7	13–67–11
4	15	Male......	$4\frac{1}{4}$	$4\frac{3}{4}$	$2\frac{1}{10}$	$5\frac{3}{4}$	14	7	13–74–11
5	$16\frac{1}{2}$	Female ...	$4\frac{1}{8}$	$4\frac{3}{5}$	2	$6\frac{1}{2}$	14	7	14–67–11
6	14	Male......	$4\frac{1}{3}$	$4\frac{1}{5}$	$2\frac{1}{8}$	$5\frac{1}{2}$	13	7	14–77–11
7	14	Female ...	$4\frac{1}{4}$	$4\frac{5}{6}$	$2\frac{1}{8}$	$5\frac{2}{3}$	13	7	13–67–11
8	$13\frac{1}{2}$	Male......	$4\frac{1}{4}$	$4\frac{1}{2}$	$2\frac{1}{8}$	$5\frac{1}{2}$	12	7	14–69–11
9	13	Female ...	$4\frac{1}{5}$	$4\frac{3}{4}$	$2\frac{1}{10}$	6	13	7	14–70–11
10	$15\frac{1}{4}$	Male......	$4\frac{1}{4}$	$4\frac{3}{4}$	$2\frac{1}{10}$	6	15	7	14–74–11
11	$15\frac{1}{2}$	Male......	4	$4\frac{3}{4}$	2	$5\frac{2}{3}$	13	7	14–70–11
12	16	Female ...	$4\frac{1}{4}$	$4\frac{3}{4}$	$2\frac{1}{10}$	$5\frac{4}{5}$	14	7	13–72–11
13	14	Male......	$4\frac{1}{4}$	$4\frac{3}{4}$	$2\frac{1}{6}$	6	12	7	13–69–11
14	15	Female ...	$4\frac{1}{4}$	5	$2\frac{1}{8}$	$5\frac{2}{3}$	13	7	14–69–10
15	$16\frac{1}{2}$	Female ...	$4\frac{1}{4}$	$4\frac{2}{3}$	2	$6\frac{1}{5}$	14	7	13–68–11
16	14	Male......	$4\frac{1}{4}$	$4\frac{3}{4}$	$2\frac{1}{8}$	$5\frac{1}{2}$	13	7	13–71–10
17	16	Female ...	4	$4\frac{4}{5}$	$2\frac{1}{10}$	$5\frac{1}{2}$	14	7	14-72–11
18	15	Male......	$4\frac{2}{5}$	$4\frac{1}{5}$	2	6	13	7	14–68–10
19	15	Female ...	4	$4\frac{1}{5}$	2	$5\frac{3}{4}$	13	7	14–72–11
20	16	Female ...	4	$4\frac{1}{2}$	2	$6\frac{1}{5}$	14	7	14–74–11
21	$13\frac{1}{2}$	Male......	$4\frac{1}{4}$	$4\frac{3}{4}$	$2\frac{1}{8}$	$6\frac{1}{2}$	13	7	13-69–10
22	$15\frac{1}{4}$	Male......	$4\frac{1}{4}$	5	2	$5\frac{1}{5}$	14	6	13–73–10
23	15	Female ...	4	$5\frac{1}{4}$	2	$6\frac{1}{4}$	14	7	13-72–10
24	15	Male......	$4\frac{1}{5}$	$4\frac{2}{3}$	$2\frac{1}{8}$	$5\frac{4}{5}$	14	7	14–71–11
25	15	Male......	$4\frac{1}{6}$	$4\frac{2}{7}$	$2\frac{1}{10}$	$5\frac{1}{2}$	13	7	14–73–11
26	15	Male......	$4\frac{1}{8}$	$4\frac{3}{4}$	$2\frac{1}{10}$	$5\frac{2}{3}$	14	7	13–68–10
27	$13\frac{1}{2}$	Male......	$4\frac{1}{4}$	$4\frac{3}{5}$	$2\frac{1}{10}$	$5\frac{3}{4}$	13	7	14–75–12
28	15	Female ...	$4\frac{1}{5}$	$4\frac{3}{5}$	$2\frac{1}{8}$	$5\frac{1}{2}$	13	7	14–72–11
29	$13\frac{1}{2}$	Female ...	4	$4\frac{2}{3}$	$2\frac{1}{10}$	$5\frac{1}{2}$	14	7	13-69–10
30	15	Male......	$4\frac{1}{5}$	$4\frac{4}{5}$	$2\frac{1}{10}$	$5\frac{3}{4}$	13	7	14–70–11
31	$15\frac{1}{2}$	Female ...	4	5	$2\frac{1}{10}$	6	13	7	14–76–10
32	$14\frac{1}{2}$	Male......	$4\frac{1}{4}$	5	$2\frac{1}{8}$	$5\frac{1}{3}$	12	7	13–71–10
33	$14\frac{1}{2}$	Male......	$4\frac{1}{5}$	$4\frac{3}{4}$	$2\frac{1}{8}$	$5\frac{1}{2}$	13 or 14	7	13–72–11
34	15	....	$4\frac{2}{5}$	$4\frac{5}{4}$	$2\frac{1}{6}$	$5\frac{1}{3}$	13	7	14–71–11
35	$14\frac{1}{2}$	....	4	5	$2\frac{1}{10}$	$5\frac{2}{3}$	13	7	14–74–11
36	14	....	$4\frac{1}{4}$	$4\frac{1}{8}$	$2\frac{1}{10}$	$5\frac{1}{2}$	13	7	14–71–11
37	$15\frac{1}{2}$	....	$4\frac{1}{5}$	$4\frac{4}{5}$	$2\frac{1}{8}$	6	12	7	14–68–10
38	$16\frac{1}{2}$	....	$4\frac{1}{5}$	$4\frac{1}{5}$	2	6	13	7	14–74–11
39	$13\frac{1}{2}$	....	$4\frac{1}{8}$	$4\frac{3}{5}$	$2\frac{1}{10}$	$5\frac{1}{2}$	13	7	14–73–11
40	$13\frac{1}{2}$	....	$4\frac{1}{4}$	$5\frac{1}{5}$	$2\frac{1}{10}$	$5\frac{1}{2}$	14	7	14–71–12
41	$12\frac{1}{2}$	Female ...	$4\frac{1}{4}$	$4\frac{3}{4}$	....	5	13	7	13–68–10
42	$12\frac{1}{4}$	Female ...	$4\frac{1}{4}$	$4\frac{2}{3}$	....	$5\frac{1}{2}$	13	7	12–72–10
43	12	Female ...	$4\frac{1}{4}$	$4\frac{1}{2}$	....	$5\frac{1}{2}$	13	7	12–72–10
44	12	Female ...	$4\frac{2}{5}$	$4\frac{3}{5}$	....	$5\frac{1}{4}$	13	7	13–68–10
45	12	Female ...	$4\frac{3}{5}$	$4\frac{3}{4}$	....	$5\frac{1}{4}$	13	7	12–71–10
248	$11\frac{1}{2}$	Female ...	$4\frac{1}{5}$	$4\frac{3}{5}$	$2\frac{2}{5}$	$5\frac{3}{4}$	13	7	13-69–10
249	$11\frac{1}{2}$	Male......	$4\frac{2}{5}$	$4\frac{1}{2}$	$2\frac{1}{4}$	$5\frac{1}{3}$	14	7	12–70–11
42*a*	$13\frac{3}{4}$	....	$4\frac{1}{2}$	5	$2\frac{1}{5}$	$6\frac{1}{3}$	15	7	14–72–13
94	$11\frac{1}{4}$	....	4	$4\frac{2}{5}$	$2\frac{1}{3}$	6	14	7	13–69–11
104	$10\frac{1}{2}$	....	4	$4\frac{1}{2}$	$2\frac{2}{5}$	$5\frac{1}{4}$	13	7	11–68–10
105	$11\frac{1}{2}$	....	$4\frac{1}{2}$	5	$2\frac{1}{4}$	6	13	7	12–65–12
109	10	....	$4\frac{1}{2}$	5	$2\frac{3}{5}$	$5\frac{1}{3}$	14	7	11-65- 9
110	$10\frac{1}{2}$	....	$4\frac{1}{2}$	$4\frac{3}{4}$	$2\frac{1}{4}$	$5\frac{1}{5}$	12	7	12–72–11
138	$5\frac{3}{4}$	....	4	4	$2\frac{1}{3}$	$5\frac{1}{3}$	14	7	12–67–10
168	$10\frac{3}{4}$	....	$4\frac{1}{3}$	$4\frac{1}{3}$	$2\frac{1}{5}$	$5\frac{3}{5}$	13	7	13–75–11
169	12	....	$4\frac{1}{3}$	$4\frac{1}{3}$	$2\frac{1}{5}$	$5\frac{1}{2}$	13	7	12–75–11
172	$12\frac{1}{4}$	....	$4\frac{1}{3}$	5	$2\frac{1}{3}$	6	13	7	13–72–11

[Introduced species] **Cyprinus carpio** Linnæus. *Carp.*

This introduced species has become well established in the lower Snake River. Several were seen at O'Brien's fishery and it was reported at Lower Salmon Falls.

5. **Acrocheilus alutaceus** Agassiz & Pickering. *Chisel-mouth; Square-mouth; Hard-mouth.*

This species was seen by us only at O'Brien's fishery below Weiser. In 1893 it was obtained in Snake River at Payette and in Boise River at Caldwell.

6. **Mylocheilus caurinus** Richardson. *Columbia Chub.*

In Snake River this minnow is one of the most abundant fishes, and is known locally by the misleading names "fresh-water herring" and "whitefish." At Upper Salmon Falls they were even called "trout." The name "whitefish" for this minnow is rather more than local in its application, as it is in use not only on Snake River but at Flathead Lake and perhaps elsewhere. At O'Brien's and Millet's this fish was very abundant, and after the salmon fishing had begun schools of 30 to 50 or more could be seen at any time. They are particularly attracted by the offal thrown into the river when the salmon are cleaned. It takes the hook very readily and possesses considerable game qualities. The best bait seems to be salmon spawn, but they will bite at almost anything—a piece of liver, heart, or a fish's eye. By throwing a few salmon eggs into the water, good-sized schools could be called up at any time. Numerous specimens were obtained at O'Brien's and Millet's, but it was not seen elsewhere except at Glenn Ferry. It does not seem to ascend the tributary streams as far as the Payette and Redfish lakes.

This fish seldom attains a length of more than a foot, and is, like most members of its family, a bony species; nevertheless it possesses some importance as a food-fish. At the hotel in Demersville, above Flathead Lake, Montana, I saw it served as "whitefish," and at certain places on Snake River it is caught and peddled over the country as "trout" or "fresh-water herring." These fish-peddlers, of course, handle salmon primarily, but other and smaller fish are thrown in when they chance to get them.

7. **Ptychocheilus oregonensis** Richardson. *Squawfish: Sacramento Pike; "Yellowbelly"; "Chub"; "Big-mouth"; "Box-head."*

This species, one of the largest of the family, is a common fish throughout the Snake River basin as far up as Shoshone Falls, above which it is not known to occur. I found it common at Millet's, Glenn Ferry, and O'Brien's, but less so than *Mylocheilus caurinus;* several large examples were seen at Lower Salmon Falls. It seems to be abundant at Big Payette Lake, while in the Redfish Lakes it is very abundant. In July it was common in the streams, but later it was rarely seen except in the lakes. It was frequently taken on the gill net set in Alturas Outlet, even in September, but the fish thus taken were probably passing from one lake to the other.

At almost any time large schools could be seen swimming slowly about the mouths of the inlets. Usually they could be seen at depths of 5 to 40 feet, but frequently in the evening they were seen swimming near the surface and feeding upon butterflies and other insects falling upon the water. Their manner of taking these insects was very much like that of the trout; indeed, so close is the resemblance that we at first supposed them to be trout. Frequently they would jump entirely out of the water, so eager were they to secure a falling insect. This was particularly observed at Redfish Lake August 20 to 23, in the evening between 6 and 8 o'clock.

Upon going out in the boat to the place where they seemed abundant, I discovered that they would rise to the fly quite freely. By using the Royal Coachman and fishing as if for trout I caught in a few minutes six good-sized "Yellowbellies." They would rise to the fly promptly, strike quickly, and fight vigorously for a few moments, after which they allowed themselves to be pulled in without much struggle. They would usually not rise to the fly except in the evening, but with a hook baited with salmon spawn they could be caught at any time.

This species is found in all the Redfish lakes, and is so abundant in one of them as to have suggested the name by which the lake is locally known, Yellowbelly Lake. In these lakes it reaches a weight of about 4 pounds, though the usual weight there is about a pound. It spawns in May. In the winter it is sought for as an article of food and is said to afford considerable sport. Dried salmon spawn is used for bait, and the fishing is done through the ice of the lakes. Pettit and Yellowbelly lakes are regarded as the best lakes for this kind of fishing.

This fish is rather bony, of course, but its considerable size reduces this objection to a minimum. When taken from these cold lakes the flesh is firm and sweet, and the "yellowbelly" must be taken into account when the game and food fishes of Idaho are under consideration.

In the following table are given comparative measurements of several examples of this species, all from Idaho:

Comparative measurements of specimens of Ptychocheilus oregonensis from Idaho.

Nos.	Head.	Depth.	Eye.	Snout.	Dorsal.	Anal.	Scales.	Length.
								Inches.
107	$3\frac{4}{5}$	$4\frac{2}{5}$	6	$3\frac{1}{5}$	9	8	16-77- 9	$12\frac{5}{8}$
108	$3\frac{3}{4}$	$4\frac{2}{3}$	$6\frac{1}{2}$	$3\frac{1}{3}$	9	8	16-73- 9	$14\frac{1}{4}$
106	$3\frac{3}{4}$	$4\frac{3}{4}$	$6\frac{1}{2}$	3	9	8	16-75- 9	$12\frac{1}{2}$
152	4	5	6	$3\frac{1}{4}$	9	8	16-73- 9	$9\frac{1}{2}$
148	4	$5\frac{2}{3}$	6	$3\frac{1}{4}$	9	8	16-78- 9	$9\frac{1}{4}$
150	$3\frac{3}{4}$	$4\frac{1}{3}$	7	3	9	8	16-76- 9	$13\frac{1}{4}$
149	$3\frac{3}{4}$	$4\frac{3}{4}$	7	3	9	8	17-75- 9	$12\frac{3}{4}$
151	$3\frac{4}{5}$	$4\frac{3}{4}$	$6\frac{3}{4}$	3	9	8	16-74- 9	13
167	$3\frac{3}{4}$	$4\frac{3}{4}$	6	3	9	8	16-72- 8	$11\frac{1}{4}$
166	4	$4\frac{1}{4}$	$6\frac{3}{5}$	3	9	8	15-74- 9	$11\frac{3}{4}$
165	4	5	6	3	9	8	16-70- 8	$13\frac{3}{4}$
164	4	5	$6\frac{1}{4}$	3	9	8	15-72- 8	$11\frac{1}{2}$
163	4	$5\frac{1}{5}$	6	3	9	8	15-75- 8	$10\frac{1}{2}$
93	4	$4\frac{3}{4}$	$6\frac{3}{4}$	3	9	8	16-75- 9	13
92	$3\frac{4}{5}$	$4\frac{1}{2}$	7	3	9	8	15-75- 9	12
101	$3\frac{4}{5}$	$5\frac{1}{2}$	$6\frac{1}{4}$	3	9	8	16-78- 8	$13\frac{1}{2}$
102	$3\frac{3}{4}$	$5\frac{1}{2}$	6	3	9	8	16-78- 8	$11\frac{1}{2}$
201	4	5	5	$3\frac{1}{3}$	9	8	15-76- 9	$7\frac{7}{8}$
204	$3\frac{4}{5}$	$5\frac{1}{4}$	$4\frac{2}{3}$	$3\frac{1}{4}$	9	8	15-74- 8	7
205	4	$4\frac{3}{4}$	5	$3\frac{1}{4}$	9	8	14-70- 8	$6\frac{5}{8}$
207	4	5	5	$3\frac{1}{4}$	9	8	15-78- 8	$6\frac{1}{4}$
202	4	$4\frac{3}{4}$	5	$3\frac{1}{5}$	9	8	16-71- 9	8
206	$3\frac{3}{4}$	$4\frac{1}{2}$	$4\frac{1}{2}$	$3\frac{1}{3}$	9	8	16-69- 9	$5\frac{7}{8}$
203	$3\frac{3}{4}$	$4\frac{2}{3}$	$4\frac{2}{3}$	$3\frac{1}{2}$	9	8	15-72- 8	7
....	$3\frac{2}{3}$	$5\frac{1}{3}$	4	$3\frac{1}{2}$	9	8	16-75- 8	....
....	$3\frac{1}{2}$	$4\frac{2}{3}$	4	$3\frac{1}{2}$	9	8	15-73- 8	....
....	$3\frac{2}{3}$	5	$3\frac{2}{3}$	$3\frac{1}{2}$	9	8	15-69- 8	....
....	$3\frac{2}{3}$	$4\frac{3}{5}$	4	$3\frac{1}{3}$	9	8	15-70- 8	....
....	$3\frac{3}{5}$	5	$4\frac{2}{3}$	$3\frac{1}{3}$	9	8	16-69- 8	....
....	$3\frac{2}{3}$	5	4	$3\frac{1}{3}$	9	8	15-73- 8	....
....	$3\frac{1}{2}$	$4\frac{3}{4}$	4	$3\frac{2}{5}$	9	8	15-75- 8	....
....	$3\frac{3}{4}$	5	$4\frac{1}{3}$	$3\frac{1}{2}$	9	8	15-73- 8	....
....	$3\frac{1}{2}$	5	4	$3\frac{2}{5}$	9	8	15-70- 8	....
....	$3\frac{1}{2}$	$5\frac{1}{2}$	$4\frac{1}{3}$	3	9	8	15-72- 8	....
....	$3\frac{1}{3}$	$5\frac{1}{5}$	4	$3\frac{1}{3}$	9	8	15-71- 8	....
....	$3\frac{1}{3}$	5	4	$3\frac{2}{5}$	9	8	15-69- 8	....
....	$3\frac{1}{2}$	5	4	$3\frac{1}{5}$	9	8	15-72- 8	....
....	$3\frac{1}{2}$	$4\frac{4}{5}$	$4\frac{1}{3}$	3	9	8	15-70- 8	....
....	$3\frac{1}{2}$	5	4	$3\frac{1}{3}$	9	8	15-69- 8	....
....	$3\frac{1}{2}$	$4\frac{2}{3}$	$4\frac{1}{2}$	3	9	8	15-71- 8	....
....	$3\frac{2}{5}$	5	4	$3\frac{1}{3}$	9	8	15-74- 8	....
....	$3\frac{1}{2}$	$4\frac{4}{5}$	4	$3\frac{1}{2}$	9	8	15-72- 8	....
....	$3\frac{4}{5}$	5	$6\frac{2}{3}$	3	9	8	16-80- 9	$14\frac{1}{2}$
....	$3\frac{1}{5}$	$4\frac{5}{6}$	$6\frac{1}{2}$	3	9	8	17-75- 9	$13\frac{1}{2}$
....	$3\frac{4}{5}$	$5\frac{1}{5}$	$6\frac{1}{2}$	3	9	8	16-73- 9	$13\frac{1}{2}$
....	$3\frac{5}{6}$	$5\frac{1}{3}$	$6\frac{1}{2}$	3	9	8	15-76-10	14

Teeth, usually 2, 4-5, 2, strong and well hooked, but without grinding surface.

8. Leuciscus balteatus (Richardson). *Shiner.*

This is one of the most abundant minnows on the west coast from Oregon to British Columbia; in the Columbia basin it is common everywhere except in Snake River above Shoshone Falls, where it is represented by the closely related species, *Leuciscus hydrophlox*. In the Snake River basin below Shoshone Falls it has been obtained at about every place where we have made collections. At the Redfish lakes it is very abundant, and is known as "shiner." At Pettit Lake a large school could be called up at any time by throwing bread crumbs, oatmeal, or the like into the lake at our camp; while in tho shallow water at the head of Pettit Outlet the young were excessively abundant. Among the vegetation off the mouth of Alturas Inlet this species was found in great numbers. On September 9, at a single haul of tho seine in 20 to 40 feet depth, about a half bushel of this species was taken. Many of them were the largest and finest individuals we have seen.

This fish was found in the stomachs of bull trout, cut-throat trout, and squawfish, and doubtless forms an important part of the food supply of those species.

Our collections contain large series of this species, chiefly from Alturas and Pettit lakes.

At one time Dr. Eigenmann thought that a certain definite relation existed between the number of anal rays in this species and the altitude of the place from which the particular specimens were obtained; or, as stated by him, "the number of [anal] rays in the species considered [*Leuciscus balteatus*] decreases with the altitude." In the light of fuller data Dr. Eigenmann now agrees with us that this generalization is not borne out by the facts.

As bearing upon this question and as showing the variations in this character among individuals from the samo locality, the following table will be instructive. In the first column are given the localities from which specimens were examined, in the second the altitude of each, in the third the total number examined from each locality, and in the following columns the number of examples having the number of anal and dorsal rays indicated by the figures at the head of each column.

Locality.	Altitude.	Total number of specimens examined.	Anal fin rays.													Dorsal fin rays.				
			11	12	13	14	15	16	17	18	19	20	21	22	Average.	8	9	10	11	Average.
	Feet.																			
Pettit Lake	7,300	480	1	20	104	190	110	45	10						14.17	6	153	268	10	9.66
Alturas Lake	7,200	939	2	65	348	367	142	11	4						13.67	1	214	83	4	9.29
Payette Lake	4,500	2		2											12		2			9
Indian Valley	3,000	21	5	5	5	3	1	1		1					12.90	1	14	6		9.23
Mann Creek	2,800	6		4	1	1									12.50		2	4		9.66
Upper Salmon Falls	2,500	1					1								15			1		10
Snake River at Weiser	2,100	3						1		1				1	18.66		1	2		9.66

9. Rhinichthys cataractæ dulcis (Girard). *Western Dace.*

The western dace seems to be a rather common species throughout the Snake River basin, both above and below Shoshone Falls. Tho species, as now understood, is one of very wide distribution, its habitat including not only the headwaters of the Missouri, Platte, Arkansas, and Rio Grande, and the entire Columbia basin, but the headwaters of the Colorado of the West and streams tributary to Great Salt Lake. Specimens were obtained by us at Upper Salmon Falls in 1894, and in Alturas Lake, Alturas Outlet, Meadow Creek, Warm Springs Creek, and Pettit Outlet. We did not see it at Redfish Lake nor is it among the collections from Payette Lake, though it doubtless occurs in those places.

10. Agosia nubila (Girard).

Found by us only in Mann Creek near Weiser and in the Little Weiser River at Indian Valley in 1894, and by Mr. Williams in Goose Creek at the head of Little Salmon River, near Meadows (1 specimen); apparently not abundant except at Indian Valley.

In their paper upon the fishes collected during the investigations in the Columbia River basin in 1892 and 1893, Gilbert & Evermann called attention to three forms or geographic races of this species centering in western Washington, about Umatilla, and about Spokane, respectively. The western Washington specimens represent typical *nubila*, with dark coloration and large scales; the Umatilla group is characterized by its paler coloration and large scales; while the Spokane group may be known by the smaller scales, the frequent absence of the barbel, and the different coloration. The

specimens of the present collection agree most nearly with the Spokane group, as may be seen from the following table. The barbel is, however, oftener present in these Idaho specimens.

The following table gives comparative measurements of 19 specimens from the three localities:

Localities.	Head.	Depth.	Snout.	Eye.	Barbel.	Dorsal.	Position of dorsal fin.	Anal.	Scales.
Indian Valley	4	$4\frac{1}{2}$	3	5	Absent	8	To front of nostril	7	69
	4	4	3	5	Present	8	To nostril	7	71
	$4\frac{1}{5}$	$4\frac{3}{4}$	3	$4\frac{3}{4}$	Absent	9	To back of orbit	7	65
	$4\frac{1}{4}$	$4\frac{3}{4}$	3	$4\frac{3}{4}$	Present	8	To middle of eye	7	59
	$4\frac{1}{8}$	$4\frac{3}{4}$	3	$4\frac{1}{2}$	....do	8	To front of pupil	7	66
	$4\frac{1}{5}$	$4\frac{1}{2}$	3	$4\frac{1}{2}$	....do	8	To nostril	7	65
	4	$4\frac{3}{4}$	3	$4\frac{1}{2}$	Present $\frac{1}{2}$.	8	To eye	7	65
	$4\frac{1}{5}$	$4\frac{1}{2}$	$3\frac{1}{5}$	4	Present	9	....do	7	60
	$4\frac{1}{4}$	$4\frac{1}{5}$	3	$4\frac{1}{5}$	....do	9	To middle of pupil	7	71
	4	$4\frac{2}{3}$	3	$4\frac{1}{3}$	....do	8	To pupil	7	64
	$4\frac{1}{3}$	5	$3\frac{1}{3}$	4	....do	8	To nostril	7	65
	$4\frac{1}{4}$	5	3	$3\frac{1}{5}$	....do	8	To front of eye	7	65
	4	5	3	4	....do	8	To nostril	7	62
	$4\frac{2}{5}$	$4\frac{4}{5}$	3	4	....do	8	To front of nostril	7	61
	4	5	3	$4\frac{1}{3}$	....do	8	To nostril	7	61
	4	5	3	4	....do	8	To pupil	7	68
Mann Creek	$4\frac{1}{3}$	$4\frac{4}{5}$	3	4	....do	8	....do	7	61
	4	5	3	$3\frac{3}{4}$	....do	8	....do	7	63
Goose Creek, Meadows, Idaho.	$3\frac{1}{5}$	$4\frac{2}{3}$	3	4	Absent	8	To front of eye	7	65

11. Agosia umatilla Gilbert & Evermann.

The only species of *Agosia* found at the Rodfish lakes agrees well with the type and description of *A. umatilla*. Our collection contains 28 specimens from Pettit Lake Outlet and 19 from Alturas Lake, all collected in July and August. It does not appear to be at all common and is not among the collections made at the Payette lakes.

12. Agosia falcata Eigenmann.

The collection made in Snake River near Weiser, Idaho, September 22, 1894, contains 66 examples of this species. It is now known from the following localities: Boise River at Caldwell, Idaho (type locality); Payette and Snake rivers at Payette; Mill Creek near Walla Walla, and Columbia River at Umatilla and Pasco.

13. Coregonus williamsoni Girard. *Rocky Mountain Whitefish; "Mountain Herring."*

This whitefish seems to be a common species in all suitable waters in Idaho. It was found by us in Snake River at Upper and Lower Salmon Falls, Glenn Ferry, and Weiser; Little Weiser River at Indian Valley; Big Payette Lake and Payette River; Redfish, Pettit, and Alturas lakes; Alturas and Pettit lake outlets, and Salmon River. The following information was given by different persons with whom we talked concerning this fish:

Charles Harvey, Lower Salmon Falls: "Common at this place; attains a weight of three-fourths of a pound, though half a pound is the usual weight; it is a very fat fish, and readily takes a hook baited with a grasshopper or grub; it probably spawns late in September."

John W. Smith, Council Valley: "There are millions of mountain herring in Payette Lake; they spawn in October, going far up tho inlet above where the redfish spawn. A few years ago we caught 2,200 at one haul of a 75 or 80 foot seine. These fish weigh about half a pound undressed, or one-third of a pound dressed."

F. C. Parks, Sawtooth: "The mountain herring are common in the Redfish lakes and connecting streams. They usually weigh about one-fourth of a pound, though I have caught them in Salmon River weighing 2 pounds. They tako the hook readily in tho spring and early summer."

Thomas McCall, Lardo: "The whitefish are very abundant in Big Payette Lake. Their spawning time is in October, when they run up the inlet in astonishing numbers. In October of the present year (1895) they wero more abundant than usual. Ten wagonloads were caught with seines and pitchforks, and as many more might have been taken without causing any appreciable decrease. They began spawning about the middle of October and the run lasted about two weeks, when the fish returned to the lake. They would average about three-quarters of a pound undressed. Many of those caught we found ready salo for in Warren and Boise at 10 to 15 cents a pound."

Mr. McCall's statement regarding this large run is rather astonishing, but seems perfectly trustworthy and is corroborated by Mr. C. R. White, postmaster at Meadows. Mr. White says:

"The run of whitefish was very remarkable last fall at Fisher Creek, above the Big Lake. Such a sight was never seen before. People went there, caught them, and loaded their wagons in a few hours' time. The people threw them out onto the bank with shovels, they were so thick, and their numbers did not seem to be decreased. The fish were very fat and plump and almost fried themselves. I am not prepared to say but that a similar run occurs every year, but it has not been noticed so much before this year. The mail carrier was building a cabin near where the fish came to spawn, and the men working upon the cabin were the first to notice the great numbers of fish."

Timothy Cooper, Stanley Basin: "Whitefish come up Stanley Lake Inlet by the thousands about October 15, and are seen for about a month, during which time they are spawning. People catch them by the hundred in dip nets."

H. H. Marshall, Stanley Basin: "The whitefish are very abundant in Stanley Lake and run up the inlet in November to spawn."

At the time of our arrival at Sawtooth, in July, whitefish were not uncommon in Salmon River and Alturas Creek, and were occasionally taken in the gill net in Alturas Outlet. At that time they took the hook freely, and several very fine catches were made by Mr. Scofield, Mr. Parks, and others. Those taken on the hook weighed about a pound each, though one was estimated at 4 pounds. The average length was about a foot. The young, still showing the parr marks, were common everywhere in shallow, quiet water, but after July the adults appeared to have gone into the deeper water of the lakes. While seining at the upper end of Alturas Lake September 9 and 10, in 20 to 60 feet of water, large numbers of whitefish were obtained. They averaged about 7 inches in length, were very fat, and when fried were most delicious, far surpassing the trout in sweetness and delicacy of flavor.

In the following table are given comparative measurements of a number of specimens of this species, all from Alturas Lake except the last two:

No.	Head.	Depth.	Eye.	Snout.	Dorsal.	Anal.	Scales.	Gillrakers.	
								Right.	Left.
95	5	4	5	$3\frac{1}{3}$	10	10	10-85-8	14+8	13+8
96	5	$4\frac{1}{4}$	$4\frac{1}{4}$	$3\frac{1}{2}$	12	10	10-78-8	12+7	11+6
97	$5\frac{1}{2}$	$4\frac{1}{2}$	$4\frac{1}{2}$	$3\frac{1}{2}$	12	10	10-86-8	15+10	13+8
98	5	$4\frac{1}{3}$	$4\frac{1}{2}$	$3\frac{2}{3}$	12	11	10-89-8	13+8	12+8
103	$4\frac{3}{4}$	5	$4\frac{1}{2}$	4	11	10	10-85-8	12+6	11+8
127	$4\frac{2}{3}$	$5\frac{1}{4}$	4	4	12	11	10-90-8	13+9	13+9
128	$4\frac{3}{4}$	$5\frac{1}{2}$	4	4	12	11	10-86-8	10+8	15+9
129	5	5	4	$3\frac{1}{2}$	12	11	10-78-8	14+10	13+9
130	$4\frac{1}{2}$	5	$3\frac{1}{2}$	$3\frac{2}{3}$	12	11	10-78-8	13+8	12+8
131	$4\frac{1}{2}$	$5\frac{1}{3}$	4	$3\frac{3}{4}$	13	12	10-84-8	10+8	11+8
132	$4\frac{1}{2}$	$4\frac{1}{2}$	$3\frac{1}{2}$	4	12	11	10-87-8	12+8	11+8
133	$4\frac{3}{4}$	5	4	4	11	10	10-92-8	12+9	15+7
134	$4\frac{1}{3}$	$4\frac{1}{3}$	4	4	12	12	10-85-8	14+8	15+10
135	$4\frac{3}{4}$	$5\frac{1}{2}$	4	$3\frac{1}{3}$	11	10	10-82-8	14+9	14+8
136	$4\frac{3}{4}$	5	$4\frac{1}{2}$	4	12	10	10-82-8	15+9	15+8
137	$4\frac{1}{4}$	5	$3\frac{1}{2}$	$3\frac{1}{2}$	11	10	9-82-8	13+7	13+7
153	5	$4\frac{1}{4}$	4	4	12	11	10-80-8	11+8	12+8
154	5	$4\frac{3}{5}$	4	4	11	11	10-79-8	12+7	14+8
155	5	$4\frac{1}{2}$	$4\frac{1}{3}$	$4\frac{1}{3}$	12	11	10-88-8	13+8	12+8
156	$5\frac{1}{4}$	$4\frac{2}{3}$	4	$3\frac{2}{3}$	13	11	10-83-8	12+9	12+10
157	$4\frac{3}{4}$	$4\frac{1}{2}$	$4\frac{1}{3}$	$3\frac{2}{3}$	12	12	10-81-8	12+9	12+9
158	$5\frac{1}{4}$	$4\frac{2}{5}$	$4\frac{1}{2}$	4	12	11	9-84-7	12+8	12+7
159	5	$4\frac{3}{5}$	$4\frac{1}{4}$	4	12	11	9-89-8	14+8	15+9
160	5	$4\frac{1}{2}$	$4\frac{3}{5}$	$3\frac{2}{3}$	10	9	9-83-8	12+9	14+8
161	5	$4\frac{2}{5}$	5	$3\frac{1}{2}$	13	12	9-81-7	13+8	14+8
162	5	5	$4\frac{2}{5}$	$3\frac{3}{5}$	12	11	9-85-7	14+9	13+8
182	$4\frac{4}{5}$	$4\frac{2}{3}$	$4\frac{2}{3}$	$4\frac{1}{4}$	11	11	9-84-7	14+7	13+6
183	5	$4\frac{1}{2}$	$4\frac{2}{3}$	4	12	11	9-85-7	12+7	14+7
184	5	$4\frac{1}{3}$	4	$3\frac{4}{5}$	12	11	9-82-8	12+8	12+8
(1)	$4\frac{3}{5}$	5	$3\frac{1}{2}$	4	12	11	9-80-8	12+7	13+7
(1)	$4\frac{1}{2}$	$4\frac{1}{4}$	$3\frac{1}{3}$	$4\frac{1}{2}$	12	11	9-82-7	13+8	12+7

[1] These two specimens obtained at Upper Salmon Falls October 2, 1894.

14. Oncorhynchus tschawytscha (Walbaum). *Chinook Salmon; Quinnat Salmon; "Dog Salmon"* of Idaho.

That part[1] of the report upon the work done in Idaho in 1894 which pertained to the salmon, redfish, and salmon trout has already been published, with a large amount of information concerning these three species, gained by interviews and through our own observations. In the present connection the details of the observations made in 1895 are given.

The following extracts from our field notes will most clearly show the condition of the upper portion of Salmon River from time to time as regards the salmon:

July 10: Mr. Timothy Cooper, who lives in Stanley Basin, 5 miles from Stanley Lake, 8 miles from Redfish Lake, or about 35 miles from Sawtooth, saw 2 salmon in Cape Horn Creek. This creek is about 15 miles northwest from Mr. Cooper's and is tributary to the Middle Fork of Salmon River. These fish were in excellent condition and were probably about the first to arrive.

July 27: Mr. Cooper noticed about 100 in the same stream, 10 of which he shot or speared. These 10 averaged about 20 pounds each and were in excellent condition, being scarcely ripe. A good many were taken by other persons.

July 24: Mr. Parks saw 4 salmon in Salmon River below mouth of Alturas Creek. These were the first seen this far up the river and were probably the first to arrive. They appeared to be in excellent condition.

July 31: Dr. Meek saw 2 salmon in Salmon River about 6 miles below mouth of Alturas Creek. No sores could be seen.

August 1: Two were seen in same place where those were seen on July 31, probably the same fish.

August 5: Dr. Meek saw 3 in Salmon River about 2 miles below mouth of Alturas Creek. No sores or mutilations could be seen.

August 6: Mr. Cooper saw 10 salmon in same stream, but did not note their condition.

August 9: One large fish seen in Salmon River 1 mile below mouth of Alturas Creek. No mutilations were noticed. Mr. A. G. Fletcher, of Camas Prairie, saw 2 salmon in Salmon River above mouth of Smiley Creek. One was dead, it having probably been shot by someone; the other was caught. It was a ripe female about 3 feet long, weighed 14 pounds, and was in good condition.

August 11: The first examples caught in our gill nets were taken to-day from the lower net in Alturas Creek. These were 2 specimens, a male and a female, 40 and 31 inches, respectively, in total length, and weighing 18 and 9½ pounds each. They were in perfect condition and were scarcely ripe.

August 13: Six salmon seen in Salmon River between mouth of Alturas and Champion creeks. Four were going up stream, each by itself, while the other 2 were spawning on the upper end of a riffle. No mutilations seen.

August 16: One male salmon was shot by Dr. Meek in Alturas Creek above the nets. It was 37½ inches long and weighed 29 pounds. It was ripe, but showed no mutilations. Two others were seen in Alturas Creek and 1 in Salmon River.

August 17: One male salmon, 31 inches long and weighing 9 pounds, taken in gill net in Alturas Creek. This fish was nearly ripe, but showed no mutilations. The stream was examined for a considerable distance, but no other salmon were seen.

August 20: One ripe male salmon weighing 25 pounds was caught in gill net in Alturas Creek; no sores or mutilations of any kind. Two others were shot in Salmon River, about a mile below mouth of Alturas Creek; they were both ripe males, weighed 22 and 26 pounds, respectively, and were in prime condition. One spent female was found dead in Alturas Creek below the net; it weighed 15 pounds, and had the caudal fin and caudal peduncle considerably mutilated. At least 10 others were seen between the net in Alturas Creek and the mouth. They were ordinarily seen alone, only 3 being seen together. When frightened, all swam downstream into deep pools.

About 2 miles of the river below the mouth of Alturas Creek were examined, and 15 salmon were found. Mr. Comstock examined a portion of the river still lower down, and saw 19 or 20 salmon, 5 of which he shot. A few of these fish showed some mutilations, but most of them appeared to be in excellent condition. Nearly all appeared to be going up stream.

August 22: One spent female was found on bank below Alturas Creek net. It was 25 inches long, and was not at all mutilated. Two others were seen in deep water a short distance below the nets in Alturas Creek. They appeared to be without mutilations, but could not be examined closely, as they hid under an overhanging bank when disturbed.

August 24: One spent female was found in Alturas Creek below the nets. It weighed 16 pounds, and the caudal and dorsal fins were badly frayed out. On this date I traveled up the river from Redfish Lake and inspected it at several places. In about 2 miles in the course of the river next above the ford, near Redfish Lake, 39 salmon were counted. They were usually in twos and threes, in shallow water, where the gravel was finest, and were evidently spawning. Some distance farther up at least a dozen were seen on one riffle, and in the next mile or two at least 75 more were seen. All appeared to be spawning, and many were in water so shallow that their dorsal fins stuck out.

The dorsal, caudal, and anal fins, in a great many cases, were more or less sore or frayed out, and in several instances the nose was sore and there was a large sore on the back at the front of the dorsal fin. In some cases this sore or abraded area was covered with a growth of fungus, presumably *Saprolegnia*.

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[1] A preliminary report upon Salmon Investigations in Idaho in 1894, by Barton W. Evermann, in Bull. U. S. Fish Commission for 1895 (1896), pp. 253-284.

The salmon now seemed to have reached their maximum number. A rough estimate, based upon the numbers seen in the portions of the stream examined, gave 20 salmon to the mile, or 400 salmon for Salmon River above Redfish Lake. This is an underestimate, for doubtless a good many escaped observation by being concealed under overhanging banks. Taking the entire spawning season, it is probable that not more than 1,000 salmon came to this portion of Salmon River in 1895. This makes a liberal allowance for salmon killed for food or other reasons by people visiting this valley.

The large number of salmon seen on this date was designated as the "second run" by a miner from Stanley Basin. He also stated that about August 14 he caught 16 fine salmon about Cape Horn.

August 26: Alturas Creek below the nets contained 9 salmon to-day. All were either spawning or were spent. Six of the 9 were covered with sores, and had the fins badly worn.

August 27: One dead salmon in Alturas Creek just below mouth of Yellowbelly Creek; length, 37 inches; weight, 16 pounds; caudal, anal, and dorsal fins all frayed out. There were also sores upon the body at base of ventrals, on caudal peduncle, on sides, and in front of the dorsal fin. Another dead fish, a partly spent male, 31 inches long and weighing 7½ pounds, was found a little lower down. It had been shot by someone, and showed but little mutilation. Two live salmon were seen at Stenton's ranch. They were on a riffle and spawning. The dorsal fin of each was badly worn. Still another was seen at the mouth of Alturas Creek. Its dorsal fin also was somewhat worn.

Below the mouth of Alturas Creek another dead spent female was seen. It was 41 inches long and weighed 23 pounds. All its fins were badly frayed, and the body was covered with numerous sores. Another, still further down, a dead, spent female, 31 inches long and weighing 8 pounds; dorsal and anal fins somewhat worn. Still another near by, a dead female, apparently spent, with fins badly worn.

Near the mouth of Champion Creek 5 salmon were seen spawning on a riffle. All were more or less sore. Just below this riffle a dead fish was found. It was 41½ inches long, weighed 19 pounds, and was much worn on the fins. Another was seen at mouth of Roaring Creek, and one was speared at mouth of Champion Creek, which weighed 24 pounds and was 43½ inches long. It was a partly spent male with fins badly frayed.

September 4: Alturas Creek and Salmon River were examined for some distance and no live salmon were seen.

September 18 to 20: Alturas Creek and Salmon River were examined on each of these three days, but no live salmon could be found. The spawning season seems to be over and all the salmon have died.

From the foregoing it appears (1) that the salmon did not reach the upper Salmon Valley until about July 24; (2) that the maximum number was attained about August 24; (3) that few if any mutilations were seen before August 20; (4) that the spawning season was entirely over and the fish all dead or gone early in September.

As regards the time of arrival at the headwaters of Salmon River, the evidence for 1894 and for 1895 agree almost exactly, and the last half of July may safely be taken as the usual time for their arrival. Farther down the river they arrive, of course, correspondingly earlier, at least as early as July 10 at Cape Horn.

The height of the spawning season appears not to be reached until about a month after the first arrivals, and after the maximum is once reached the spawning continues for only a few days, apparently for not more than two weeks.

The worn and mutilated condition of the fish toward the close of the season, and the numerous dead fish seen, indicate with almost absolute certainty that the salmon which come to these waters never return to the sea, but all die. While not actually proved, all the facts indicate that this is true, and I have no doubt that such is the case.

And now as to the mutilations: The observations of this single season furnish abundant evidence to prove absolutely that the fraying out of fins, abrasions, sores, etc., are not injuries received while on their way up from the sea, but are practically wholly the result of contact with the gravel of their spawning-beds, plus some injuries inflicted upon each other on the spawning-grounds. During the early part of the season all the fish were perfect and entirely free from mutilations, while toward the end nearly every fish was more or less injured. The injuries are undoubtedly received on the spawning-grounds and in the ways described in detail under the redfish on page 191.

So far as we were able to learn from our observations and from interviews, the chinook salmon rarely ascends Salmon River more than a mile or two above the mouth of Alturas Creek. More fish go up Alturas Creek than up Salmon River above the union of those two streams. At present they do not appear to run up Alturas Creek more than 1 or 1½ miles above its mouth, and, with one exception, all persons who gave information concerning the salmon in former years agreed that it never ran up Alturas Creek any farther than it does at present. The one exception is Mr. R. E. Carroll, a prospector who has been more or less familiar with this region for 25 years. He first visited Alturas Lake in August, 1867, at which time he says salmon were excessively abundant in Alturas Lake, and were spawning all around the lake. Did not see any in the inlet, but saw some below the lake. Was at

the lake again in 1872 and 1876. There were salmon in the lake at each of those visits, but they were not nearly so numerous. Admitting that Mr. Carroll was not mistaken, it is quite certain that the chinook salmon does not now enter any of these lakes.

In the last mile of Alturas Creek, and in Salmon River from a mile above its union with Alturas Creek down to the outlet of Redfish Lake, the salmon has spawning-beds in all suitable places. The most suitable bottom is that composed of fine gravel with a liberal matrix of coarse sand. On these beds the water will vary in depth from a few inches to 2 feet, and the current will usually be moderately swift. In deeper water the current is not strong enough and the bottom is too sandy; where the current is strongest the proportion of large gravel is too great.

It has often been said that salmon are always headed upstream when seen, and that they are never seen to go downstream. This is not altogether true. It is probably true that while en route to the spawning-beds the salmon rarely, if ever, turn and swim downstream even for a short distance, but when on their spawning-grounds, though always headed upstream when comparatively quiet, one may frequently see them swimming downstream when chasing each other, either in playful or fighting mood. And when disturbed by anyone on the bank they will very often turn tail and swim downstream until a deep hole is reached.

No salmon were seen or heard of at Big Payette Lake by Mr. Williams until August 1. On that date Mr. E. D. York reported seeing 4 salmon in a deep pool in Payette River about 3 miles below the lake. On August 2 and 3 Mr. Williams examined the river for some distance below the lake, but saw no salmon. On August 4 a large seine was used in the river about 5 miles below the lake, and salmon were found in considerable numbers. Several hauls were made, resulting in a catch of 25 salmon, 11 males and 14 females, the lengths and weights of which are given in the accompanying table. All of these fish were in perfect condition, none of them showing mutilations or sores of any kind. Nearly all seemed to be almost ripe with spawn. The stomachs of all were examined, but no food was found in them. On August 7 six more salmon were taken, and on August 11 six others were caught. All of these were in perfect condition.

The seine was used again August 16, when 9 were taken, and again the next day, when 42 more were gotten; 35 of these were taken at one haul. This was about 5 miles below the lake. The river was seined at various places on down for about 5 miles farther, but salmon were scarce in the lower part, which seems to be about the lower limit of their spawning-grounds. In a deep pool about 8 miles below the lake a large number of salmon were seen. All of those caught were in excellent condition. They had not begun spawning.

On August 23 the river was examined again; many salmon were seen, but none had yet begun to spawn. On August 28 salmon were seen in considerable numbers and some were probably spawning. During the two weeks following August 28 the spawning season seemed to be at its height. On September 14 some spent fish were examined, and many were seen more or less covered with sores and with fins considerably worn.

Lengths and weights of chinook salmon taken in Payette River near Big Payette Lake in August, 1895, and examined by Mr. Williams.

Date.	Sex.	Length in inches.	Weight in pounds.	Date.	Sex.	Length in inches.	Weight in pounds.
Aug. 4	Female ...	27	7.5	Aug. 4	Female ...	29	9
4	Female ...	29	9.5	4	Female ...	29	10
4	Female ...	27	8	4	Female ...	29.5	9
4	Female ...	33.5	13	4	Male......	30	12
4	Female ...	36.5	19	4	Male......	30	10
4	Female ...	32	12.5	4	Male......	27	7.5
4	Female ...	30	10.25	4	Male......	30.5	10
4	Female ...	30	10.25	4	Male......	30	9.5
4	Female ...	28	8	4	Male......	28.5	9.5
4	Female ...	33.5	13.5	4	Male......	30.5	9.5
4	Female ...	32	11	4	Male......	30	9.5

Lengths and weights of chinook salmon taken in Payette River near Big Payette Lake in August, 1895, and examined by Mr. Williams—Continued.

Date.	Sex.	Length in inches.	Weight in pounds.	Date.	Sex.	Length in inches.	Weight in pounds.
Aug. 4	Male......	30	9	Aug. 17	Female ..	34	12
4	Male......	32	10	17	Female ...	32	11.5
4	Male......	29.5	9	17	Female ...	28	8
7	Male......	26	6.5	17	Female ...	28	8
7	Male......	27	7	17	Female ...	29.5	9
7	Male......	26	6	17	Female ...	30	11
7	Male......	33.5	13	17	Female ...	30	10
7	Male......	18.5	2.5	17	Female ...	29	9
7	Female ...	30.5	10	17	Female ...	29	8.5
11	M le......	30	8	17	Female ...	29.5	9
11	Male......	26.5	7	17	Female ...	29.5	9
11	Male.....	32	10	17	Female ...	30	9.5
11	Male......	18	2	17	Female ...	31	10
11	Female ...	28	8.5	17	Female ...	29.5	10
11	Female ...	27	8	17	Female ...	27.5	7
11	Female ...	36	10	17	Female ...	30	9.5
16	Male......	26	6	17	Female ...	29	9.5
16	Male......	29	8	17	Male......	29	9
16	Male......	27	6.5	17	Male......	30	9
16	Male......	28.5	8	17	Male......	37	17
16	Male......	28	8	17	Male......	28	7
16	Female ...	31	11	17	Male......	29.5	8
16	Female ...	31.5	11	17	Male......	27	6.5
16	Female ...	31	11	17	Male......	28.5	8.5
16	Female ...	30	9	17	Male......	31.5	10.5
17	Female ...	31	11	17	Male......	29	8.5
17	Female ..	28	7.5	17	Male......	32	11
17	Female ...	29	9.5	17	Male......	27	7.5
17	Female ...	36	18.5	17	Male......	30	10
17	Female ...	29	10	17	Male......	30.5	10
17	Female ...	28	8	17	Male......	28.5	8.5

The total number of salmon examined by Mr. Williams, as per above table, is 84, of which 39 were males and 45 were females. The average length of the males was $29\frac{1}{4}$ inches, the average weight $8\frac{3}{5}$ pounds; of the females the average length was $30\frac{1}{3}$ inches and the average weight $10\frac{8}{9}$ pounds. The average for the 84 was: Length, $32\frac{1}{28}$ inches; weight, $9\frac{11}{28}$ pounds.

During the fishing season of 1894 (September to November), at Upper Salmon Falls, Mr. Millet weighed and measured a total of 863 chinook salmon. Of these, 701 were males and 162 females. The minimum, maximum, and average lengths and weights are shown in the following table:

Sex.	Number of fish examined.	Length in inches.			Weight in pounds.		
		Minimum.	Maximum.	Average.	Minimum.	Maximum.	Average.
Male	701	15	46	30	2	39	$13\frac{7}{10}$
Female	162	20	40	$33\frac{9}{20}$	7	28	$14\frac{4}{5}$

The average length of all, both males and females, is 30.3 inches, and the average weight about 14 pounds.

Young salmon.—Young salmon were found in abundance in many places. At the head of Alturas Lake July 20, August 9, and September 9 and 10 numerous specimens were collected. They appeared to be most numerous at this place August 9. In the small creek at White's Warm Springs 5 small specimens were collected July 23. In Meadow Creek, on July 30, numerous specimens were obtained. In Alturas Inlet, about half a mile above the lake, Dr. Meek caught a $3\frac{1}{2}$-inch chinook salmon on a hook, using a redfish egg for bait.

The table on pages 185 and 186 shows the total lengths and comparative measurements of a number of these specimens. The following table gives the number of specimens now in the collections and the minimum, maximum, and average lengths of those collected on each of the various dates:

Date.	Locality.	Number of specimens.	Minimum length.	Maximum length.	Average length.
			Inches.	*Inches.*	*Inches.*
July 20	Alturas Lake	5	$2\frac{3}{4}$	3	$2\frac{4}{5}$
23	Warm Springs Creek	5	$1\frac{5}{8}$	$2\frac{3}{4}$	$2\frac{1}{40}$
30	Meadow Creek	83	$1\frac{3}{8}$	$3\frac{1}{8}$	$2\frac{1}{5}$
Aug. 9	Alturas Lake Outlet	50	$1\frac{3}{4}$	$3\frac{3}{8}$	$2\frac{1}{6}$
Sept. 7	Alturas Inlet	1	$3\frac{1}{2}$	$3\frac{1}{2}$	$3\frac{1}{2}$
9	Alturas Lake	5	$3\frac{1}{8}$	$3\frac{3}{4}$	$3\frac{1}{2}$
10	.....do	2	$3\frac{1}{2}$	$3\frac{7}{8}$	$3\frac{11}{16}$

An inspection of this table will give some idea of the rate of growth. The few specimens collected July 20 were probably selected because of their large size, and are likely larger than the average at that date. While the table is scarcely available for showing the rate of increase from date to date, it clearly shows a general increase. There is close agreement in size among those taken on any one date, and it is quite certain that all these young salmon were hatched from eggs laid during the spawning season of 1894. The maximum and minimum sizes are so close to the averages as to establish this fact beyond doubt. It is further certain that the fish which hatched from the eggs spawned in 1893 were not to be found in these waters in July, August, and September, 1895.

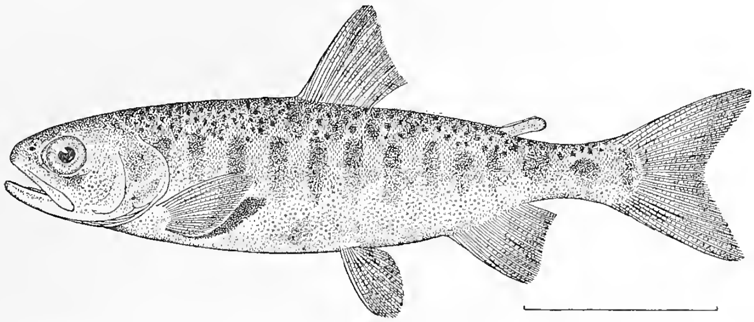
We are not yet able to say just when the young salmon leave the waters where they were hatched and begin their journey to the sea, but it undoubtedly occurs some time between September of the first and July of the second year following that in which they were spawned; thus, a young salmon which was spawned in Alturas Creek in August, 1894, would leave that locality at some time between September, 1895, and July, 1896. The probabilities are that eggs deposited in these waters in August hatch early in the spring of the following year and the young go down the river during the high water of the next spring. But this remains to be proved.

Wanderings of the young salmon.—As already stated, the only spawning-beds of the salmon in the Sawtooth region are in Salmon River itself and in the lowermost mile of Alturas Creek. By reference to the table of localities from which young salmon were collected, it will be seen that they had scattered greatly from where they were hatched. They were found in Warm Spring Creek 3 or 4 miles from the nearest spawning-beds, and the head of Alturas Lake where they were common is at least 5 miles above where they could have been spawned, and one was caught and others seen in the inlet some distance above the lake. From these facts it would appear that after hatching, the young salmon spread into all the suitable waters in the vicinity, entering the shallow waters of the sloughs, smaller creeks, and little ponds along the streams (where the minute forms of animal and plant life suitable for food are abundant), apparently more prone to run up stream than down, and thus reach the lakes above and even their inlets, where they find an ample food supply among the heavy growth of aquatic vegetation at various places in the lakes.

Young salmon taking the hook.—At various times in September young salmonids were seen in the last mile of Alturas Inlet, which were probably all of this species. They were apparently 2 to 4 inches long and were noticed only in the quiet parts of the stream, where they kept very still, swimming about very little, after the manner of *Lepomis*. When tempted with the artificial fly or baited hook they would rise to it, but usually very slowly, and after inspecting it closely, would seize it and start downward. They were not at all voracious, but would generally rise to the hook in a very deliberate way. We at first regarded them as small trout, but on September 7, when Dr. Meek caught a $3\frac{1}{2}$-inch specimen, examination showed it to be a young chinook salmon, and I am inclined to think all the small fish in Alturas Inlet which we thought to be trout were really salmon. The fact that no large trout were seen in the inlet is additional evidence that these were salmon.

While these young salmon would rise to the fly, they would rarely take it in their mouths. After slowly and carefully inspecting it they would usually slowly sink to deeper water. If the hook were baited they would often attempt to take it, but our smallest hooks were too large for such small fish, and we succeeded in landing only one.

The color of these young salmon may be thus described: Side with about 10 rather distinct bluish vertical bars, each about two-thirds diameter of eye, extending across the lateral line, the upper end of each broken up into spots, the lower ending more definitely about midway between lateral line and median ventral line; back and upper part of sides covered irregularly with small dark spots; belly and lower part of sides silvery, but thickly covered with fine dark punctulations, these also covering all other parts of the body; lower jaw pale, with many fine dark specks, rest of head appearing bluish-black from the very numerous fine specks.



Young Chinook Salmon (*Oncorhynchus tschawytscha*), drawn from an example 4 inches long caught in Alturas Lake, Idaho, September 9, 1895.

Eighty-three specimens, averaging about 2 inches in length, give the following average comparative measurements: Head $3\frac{1}{4}$ to $3\frac{2}{3}$; depth 4 to $4\frac{1}{2}$; eye $2\frac{1}{2}$ to 3; snout 4.

Young chinook salmon of this size so closely resemble young cut-throat trout that they can not be distinguished without close observation. The difference in the size of the anal fin (14 to 17 rays in the salmon, and only 10 to 12 in the trout) is the best differential character, but the following characters are also of value: In the salmon the first anal rays are produced, thus making the fin decidedly falcate, the maxillary is longer and more slender, the snout a little more pointed, the mouth less oblique, and the color not quite so dark as in the trout.

From young redfish of the same size the chinooks may be distinguished by the deeper body, darker coloration, falcate anal fin, and the much shorter and less numerous gillrakers.

Lengths and comparative measurements of specimens of young chinook salmon.

Locality and date.	Length.	Head.	Depth.	Snout.	Eye.	Locality and date.	Length.	Head.	Depth.	Snout.	Eye.
Alturas Lake, July 20	$2\frac{3}{4}$	4	$4\frac{1}{4}$	4	3	Meadow Creek, July 30	$2\frac{1}{2}$	$3\frac{1}{2}$	$4\frac{1}{5}$	4+	$2\frac{3}{4}$
	$2\frac{7}{8}$	$2\frac{4}{5}$	$3\frac{4}{5}$	4	3		$2\frac{3}{8}$	$3\frac{2}{3}$	4	4	3
	$2\frac{3}{4}$	4	$4\frac{1}{4}$	4	3		$2\frac{3}{8}$	$3\frac{1}{2}$	4	4	3
	$2\frac{3}{4}$	$3\frac{4}{5}$	$4\frac{1}{5}$	4	3		$2\frac{1}{4}$	$3\frac{1}{2}$	$4\frac{1}{5}$	4	3
	$2\frac{5}{8}$	$3\frac{4}{5}$	$4\frac{1}{4}$	4	3		$2\frac{1}{2}$	$3\frac{1}{2}$	4	4	$3\frac{1}{3}$
Meadow Creek, July 30	$1\frac{7}{8}$	$3\frac{1}{2}$	$4\frac{1}{4}$	4+	3		$2\frac{1}{4}$	$3\frac{1}{2}$	$4\frac{1}{5}$	4	3
	$2\frac{1}{8}$	4	$4\frac{1}{2}$	4	3+		2	$3\frac{1}{2}$	$4\frac{1}{5}$	4	3
	$1\frac{7}{8}$	$3\frac{1}{2}$	$4\frac{1}{2}$	4	3+		2	$3\frac{3}{5}$	$4\frac{1}{5}$	4	3
	$1\frac{3}{4}$	$3\frac{2}{5}$	$4\frac{1}{2}$	4	$2\frac{1}{3}$		$2\frac{1}{4}$	$3\frac{1}{2}$	$4\frac{1}{5}$	4	3
	$2\frac{3}{4}$	$3\frac{2}{3}$	4	4	3		$2\frac{1}{8}$	$3\frac{2}{3}$	$4\frac{1}{5}$	4	$2\frac{1}{2}$
	$2\frac{7}{8}$	$3\frac{2}{3}$	4	4	$3\frac{1}{5}$		2	$3\frac{1}{4}$	4	4+	3
	$2\frac{3}{4}$	$3\frac{2}{3}$	$3\frac{2}{3}$	4	$3\frac{1}{4}$		2	$3\frac{3}{4}$	$4\frac{2}{5}$	4+	$2\frac{1}{4}$
	2	$3\frac{1}{2}$	4	4	3		$2\frac{1}{8}$	$3\frac{3}{5}$	$4\frac{1}{4}$	$4\frac{1}{4}$	$2\frac{2}{3}$
	$2\frac{1}{4}$	$3\frac{2}{3}$	$4\frac{1}{5}$	4	3		2	$3\frac{1}{2}$	4	5	$2\frac{1}{2}$
	$2\frac{3}{4}$	$3\frac{3}{5}$	4	4	3		$2\frac{1}{8}$	$3\frac{1}{2}$	4+	4	3
	$2\frac{1}{2}$	$3\frac{2}{3}$	$4\frac{1}{5}$	4	3		$2\frac{3}{8}$	$3\frac{3}{4}$	$4\frac{1}{2}$	4	3
							$1\frac{7}{8}$	$3\frac{1}{2}$	4	4	$2\frac{3}{5}$

Lengths and comparative measurements of specimens of young chinook salmon—Continued.

Locality and date.	Length.	Head.	Depth.	Snout.	Eye.
Meadow Creek, July 30........	$3\frac{1}{8}$	$3\frac{3}{4}$	4	4	$3\frac{1}{3}$
	$3\frac{1}{4}$	$3\frac{3}{4}$	$4\frac{1}{5}$	4	$3\frac{1}{2}$
	$1\frac{7}{8}$	$3\frac{1}{2}$	$4\frac{1}{3}$	$4\frac{1}{3}$	$3\frac{1}{2}$
	$2\frac{1}{4}$	$3\frac{1}{2}$	4	4	$3\frac{1}{3}$
	$2\frac{5}{8}$	$3\frac{3}{4}$	4	$4\frac{1}{4}$	3
	$2\frac{1}{2}$	$3\frac{3}{4}$	$4\frac{1}{4}$	4	$3\frac{1}{3}$
	$1\frac{3}{4}$	$3\frac{1}{2}$	$4\frac{1}{2}$	$4\frac{1}{4}$	$2\frac{3}{4}$
	$2\frac{5}{8}$	$3\frac{3}{4}$	4+	4	$3\frac{1}{5}$
	$1\frac{5}{8}$	$3\frac{2}{3}$	4+	4	$3\frac{1}{5}$
	$2\frac{1}{8}$	$3\frac{1}{2}$	4	4	3
	$2\frac{1}{8}$	$3\frac{1}{2}$	$4\frac{1}{4}$	$4\frac{1}{2}$	3
	2	$3\frac{1}{2}$	$4\frac{1}{2}$	$4\frac{1}{4}$	3
	2	$3\frac{1}{2}$	$4\frac{1}{2}$	$4\frac{1}{2}$	3
	$2\frac{1}{4}$	$3\frac{1}{2}$	$4\frac{1}{4}$	4	$3\frac{1}{2}$
	$2\frac{1}{4}$	......	......	......	......
	$2\frac{1}{4}$	......	......	......	......
	$2\frac{1}{4}$	......	......	......	......
	2	......	......	......	......
	$1\frac{7}{8}$	......	......	......	......
	$2\frac{1}{4}$	......	......	......	......
	$2\frac{1}{8}$	......	......	......	......
	$2\frac{5}{8}$	......	......	......	......
	$2\frac{1}{4}$	......	......	......	......
	$2\frac{1}{2}$	......	......	......	......
	$2\frac{1}{2}$	......	......	......	......
	$2\frac{1}{8}$	......	......	......	......
	$2\frac{7}{16}$	......	......	......	......
	$1\frac{3}{4}$	......	......	......	......
	$2\frac{1}{2}$	......	......	......	......
	$1\frac{7}{8}$	......	......	......	......
	$1\frac{3}{4}$	......	......	......	......
	$2\frac{7}{16}$	......	......	......	......
	2	......	......	......	......
	$1\frac{1}{2}$	......	......	......	......
	$1\frac{7}{8}$	......	......	......	......
	$1\frac{7}{8}$	......	......	......	......
	2	......	......	......	......
	$1\frac{3}{8}$	......	......	......	......
	2	......	......	......	......
	3	......	......	......	......
	2	......	......	......	......
	3	......	......	......	......
	$2\frac{7}{16}$	......	......	......	......
	$1\frac{7}{8}$	......	......	......	......
	$2\frac{3}{8}$	......	......	......	......
	$2\frac{1}{4}$	......	......	......	......
	$1\frac{7}{8}$	......	......	......	......
	2	......	......	......	......
	$2\frac{1}{8}$	......	......	......	......
	$2\frac{1}{8}$	......	......	......	......
	$2\frac{1}{4}$	......	......	......	......
	$2\frac{1}{8}$	......	......	......	......
	2	......	......	......	......
	$1\frac{3}{4}$	......	......	......	......
	$1\frac{7}{8}$	......	......	......	......

Locality and date.	Length.	Head.	Depth.	Snout.	Eye.
Alturas Outlet, August 9.....	$2\frac{3}{4}$	......	......	......	......
	3	......	......	......	......
	$2\frac{1}{2}$	......	......	......	......
	$2\frac{1}{4}$	......	......	......	......
	$2\frac{7}{8}$	......	......	......	......
	$2\frac{1}{2}$	......	......	......	......
	$2\frac{1}{8}$	......	......	......	......
	$2\frac{1}{2}$	......	......	......	......
	$2\frac{1}{4}$	......	......	......	......
	$2\frac{1}{8}$	......	......	......	......
	$2\frac{7}{8}$	......	......	......	......
	$2\frac{1}{8}$	......	......	......	......
	$2\frac{1}{2}$	......	......	......	......
	$2\frac{1}{4}$	......	......	......	......
	$2\frac{1}{2}$	......	......	......	......
	$2\frac{1}{4}$	......	......	......	......
	$2\frac{7}{8}$	......	......	......	......
	$2\frac{5}{8}$	......	......	......	......
	$2\frac{3}{8}$	......	......	......	......
	$2\frac{3}{8}$	......	......	......	......
	$2\frac{1}{2}$	......	......	......	......
	$2\frac{3}{8}$	......	......	......	......
	$2\frac{1}{8}$	......	......	......	......
	$2\frac{1}{8}$	......	......	......	......
	2	......	......	......	......
	$2\frac{1}{4}$	......	......	......	......
	$1\frac{7}{8}$	......	......	......	......
	$1\frac{3}{4}$	......	......	......	......
	2	......	......	......	......
	$3\frac{3}{8}$	......	......	......	......
	$2\frac{3}{4}$	......	......	......	......
	$2\frac{3}{4}$	......	......	......	......
	$2\frac{5}{8}$	......	......	......	......
	$2\frac{7}{8}$	......	......	......	......
	$2\frac{1}{2}$	......	......	......	......
	3	......	......	......	......
	3	......	......	......	......
	$2\frac{3}{8}$	......	......	......	......
	$2\frac{1}{2}$	......	......	......	......
	$2\frac{1}{8}$	......	......	......	......
	$2\frac{3}{8}$	......	......	......	......
	$2\frac{5}{8}$	......	......	......	......
	$2\frac{1}{2}$	......	......	......	......
	$2\frac{1}{8}$	......	......	......	......
	$2\frac{1}{4}$	......	......	......	......
	$2\frac{1}{4}$	......	......	......	......
	$2\frac{1}{4}$	......	......	......	......
	$2\frac{1}{4}$	......	......	......	......
	$2\frac{1}{4}$	......	......	......	......
	$1\frac{7}{8}$	......	......	......	......
Alturas Inlet, September 7..	$3\frac{1}{2}$	4	4	$4\frac{1}{2}$	3
Alturas Lake, September 9..	$3\frac{3}{8}$	4	$4\frac{1}{4}$	$4\frac{1}{4}$	$3\frac{1}{5}$
	$3\frac{3}{4}$	4	$4\frac{1}{6}$	5	$3\frac{2}{3}$
	$3\frac{1}{8}$	4	$4\frac{1}{3}$	$4\frac{1}{4}$	$3\frac{1}{6}$
	$3\frac{5}{8}$	4+	$4\frac{1}{5}$	4+	$3\frac{1}{3}$
	$3\frac{3}{4}$	4	4	4+	$3\frac{1}{4}$

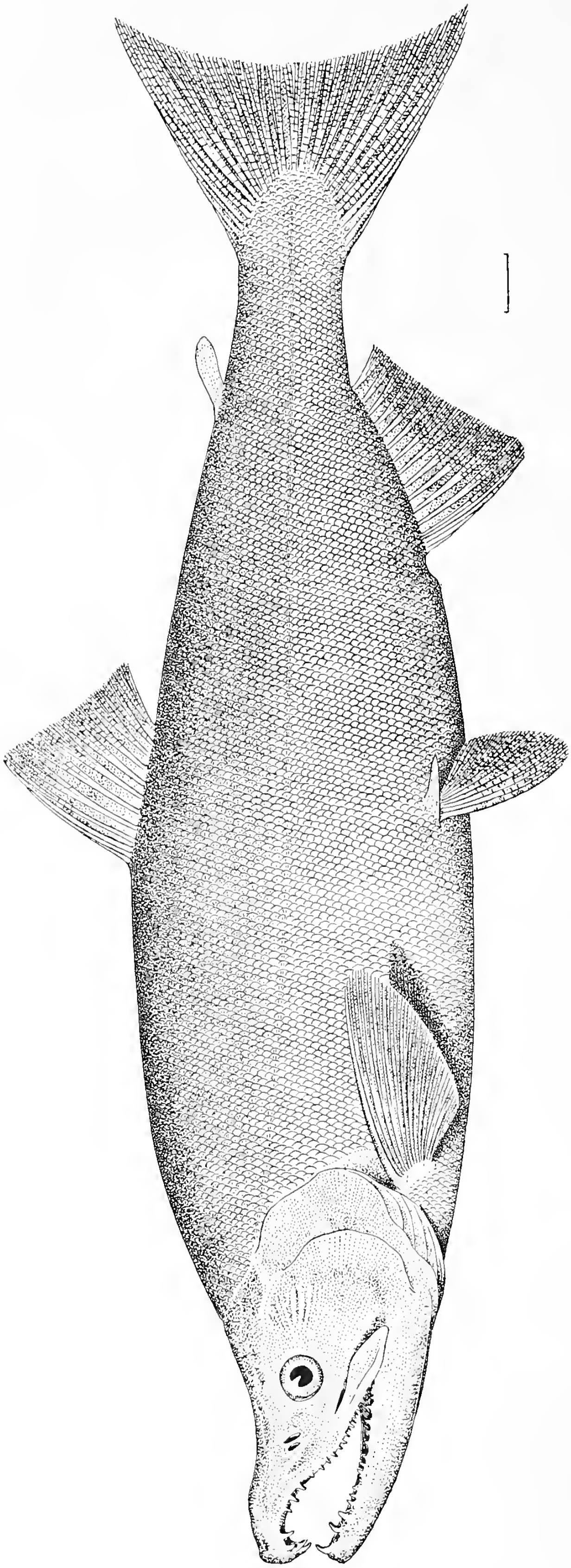


Fig. 1. BREEDING MALE REDFISH (*Oncorhynchus nerka*). Length 24 inches. Alturas Creek, Idaho, September 5, 1895.

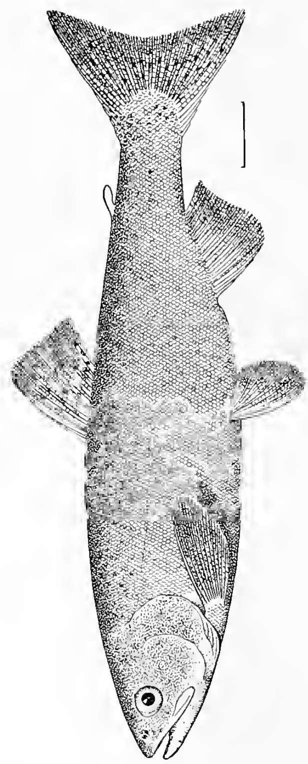


Fig. 2. BREEDING FEMALE REDFISH (*Oncorhynchus nerka*). Length 11¼ inches. Alturas Creek, Idaho, September 2, 1895.

These two illustrations are drawn on the same scale and show the relative difference in size between the large and small forms of this species.

15. Oncorhynchus nerka (Walbaum). *Redfish; Blueback Salmon; Fraser River Salmon; Saw-Qui Salmon; Saukeye Salmon; Krasnaya Ryba; Walla.*[1]

The information obtained concerning the redfish during my visit to Idaho in 1894 has been published in the report already referred to. The observations made in 1895 were much more extended and are here given with considerable detail:

July 20: Nets were set in both the outlet and inlet of Alturas Lake.

July 25: Four small redfish were found on net in Alturas Inlet. All were caught going upstream; 3 were males and 1 was a female; all were unripe and in perfect condition. This net had been examined July 22, 23, and 24, and no fish either found on it or seen in the creek or lake; these 4 fish therefore seem to be the first arrivals in the inlet. The fact that none had been taken by the net in Alturas Outlet indicates pretty conclusively that the redfish had reached Alturas Lake earlier than July 20.

July 28: As the Alturas Inlet net was being surreptitiously relieved of its catch by persons not interested in the study of the migration of fishes, and as the fact of their arrival had already been determined, the inlet net was taken up and not put in again until August 2.

August 2: An inspection of Alturas Inlet on this date showed that the redfish had entered it in large numbers. At two hauls with a 30-foot seine 56 fish were caught from one hole 4½ feet deep. Of these, 18 were females and 38 males, and all were of the small form. A few of these were ripe, but the majority were firm. All were in excellent condition, none showing any mutilations. At this time they were in bunches in the deeper pools, very few being seen upon the riffles.

August 3: The net to-day contained 2 ripe males and 2 ripe females going upstream, and 4 nearly ripe males apparently going down. Eight others, 3 males and 5 females, were caught about 2 miles up the creek. One male and 1 female were partly spent, the female having only about half a dozen eggs left. Later in the day 15 males and 5 females were taken from the same hole from which the 56 were taken on the 2d. Some of these were ripe, but none were spent and none showed any mutilations.

August 4: Two ripe males and 4 scarcely ripe females in net, 2 of the females apparently going downstream. All in perfect condition.

August 6: Two males and 3 females in net, all going upstream; none ripe and no sores.

August 6 and 7: Ralph Calderwood, of Pioneerville, Idaho, caught 130 redfish in Alturas Inlet near the forks. Of these, about 33 were females; a few had spawned, a few others were about ready to spawn, but the majority were not yet ripe. There were no blemishes or sores on any of them. They were estimated by Mr. Calderwood to weigh half a pound or less each. He thinks he saw about 1,000 redfish in the inlet, all being of the small form.

August 8: A. L. Davis, of Bellevue, Idaho, caught 3 small redfish in the inlet.

August 9: Mr. Davis caught 9 redfish about a quarter of a mile above mouth of inlet. Most of them were males, none ripe. Saw perhaps 50 others. A party of campers from Bellevue caught 49 redfish in Alturas Inlet, only 3 being females. Few, if any, were ripe and none showed any sores.

August 10: The gill net in Alturas Inlet to-day caught 3 redfish, all ripe males and in perfect condition. Two were of the small form (12½ inches long or one-half pound each), the other, a large one, 25¾ inches long and weighing 6 pounds (or 5¼ pounds dressed). On same day we speared 3 males and 1 female in a pool about three-fourths of a mile above mouth. All were ripe and without mutilations. The Bellevue party caught with spears, jigs, or gaff hooks, 84 redfish, 59 males and 25 females. Of the 84, only 3 had the fins noticeably frayed, one had the caudal badly frayed, and the other 2 were less worn. Perhaps others may have had some slight mutilations, but a somewhat close inspection failed to disclose any. Very few of this lot were ripe, and none spent. All were taken in deep holes 1 to 1½ miles above the lake. Many others were seen. An examination of the last mile of the inlet to-day showed about 175 redfish, all small and all lying in the deeper holes. The net in Alturas Inlet was taken up to-day and kept out until August 30.

August 14: One large redfish, 24½ inches long and weighing 5¼ pounds, was taken in the net in the south inlet of Pettit Lake. This was a ripe female and contained exactly 910 eggs by actual count. I do not think she had begun spawning. This net was set July 29; it had, therefore, remained in 15 days before catching any fish.

August 22: Another large redfish on same net, a ripe male 26½ inches long and weighing 5¾ pounds. No mutilations on either of these.

August 28: The camp was moved from Pettit Lake to Alturas Inlet, and daily observations were continued there for more than three weeks.

August 29: Counted 80 small and 1 large redfish in Alturas Inlet between camp (half a mile above mouth) and a point an eighth of a mile above. They were mostly on fine gravelly riffles or in deep holes next below the riffles, and were evidently spawning. When disturbed they would drop downstream into the holes, but would very soon return to the spawning-beds. Perhaps 1 out of every 8 was more or less sore. The large one was a ripe male in perfect condition. A pair spawning in a pool near our camp was watched for some time. They would come up to the little pool together, the female usually just ahead of the male. After resting quietly a few moments she would turn somewhat on one side, wriggle her body vigorously, and move the gravel about chiefly with the anal fin and the lower caudal lobe, the male being close behind her all the time. Sometimes she would turn so far over as to bring her side and back in contact with the heaped-up gravel and sand. After moving the gravel she would circle around downstream a few feet and return to the bed to repeat the same act, followed

[1] This name was heard applied to the small redfish at Alturas Lake.

closely by the male. A bunch of a dozen in a pool just below the camp was watched from day to day and their movements were essentially the same as those just described. At first we thought that only the females pushed the gravel about, but we soon saw that the males quite often did the same.

There is always a pairing off of the sexes, and as there are usually several more males than females on any spawning-bed the supernumerary males are chased about and driven away by the paired ones. They never stay away, however, but promptly return, only to be chased away again. This is kept up all day, and in water usually only a few inches deep, often no deeper than the fish itself. The fins and even parts of the body are in this way, as well as when moving the gravel on the beds, brought in contact with the gravel and sand and become quite as much worn as those of the females.

An examination of about 2 miles of the creek to-day showed that the fish are most abundant in the second mile above the lake. Throughout the lower mile the fish were not only less abundant, but not many of them were spawning; but in the upper portion of the stream they were much more abundant and nearly all spawning at this time. It was also noticed that a much larger proportion of those in the upper portion were mutilated and sore on the back or caudal peduncle.

August 30: The upper portion of the inlet was examined again to-day and the fish were found even more abundant than yesterday. Practically all were upon the riffles and spawning; a few were seen in deep holes, but they all seemed to be fishes that were done spawning, as they showed mutilations quite plainly. Four which I caught with my hands were badly worn. To-day a gill net (which I shall call Net B) was set in the inlet near our camp, half a mile above the lake.

August 31: This morning the net contained 20 small redfish; of these, 10 were going up (7 males and 3 females) and 10 (7 males and 3 females) apparently going down. These were all ripe, or nearly so, and all in excellent condition; no sores on any and the flesh quite firm in nearly all. In the lower portion of the stream to-day the fish are rather more numerous than yesterday; most of them keep quietly in the deeper holes and do not appear to be quite ready to spawn. Net C was set to-day a few feet below Net B, and a third one (D) was placed in the mouth of the inlet only a few feet from the lake. These three nets we hoped would enable us to determine whether the fish are running up or down, or both.

September 1: Net B, 24 males and 6 females, of which 16 males and 2 females were going up, while the 12 remaining appeared to have been going down, but some of them may have turned in the net; of these 30 specimens, 6 were gilled during the afternoon of August 31 before we put in Net C; of the 12 males gilled from below, 10 were almost ripe and 2 were partly spent; of the 12 apparently gilled from above, 2 females were ripe, 1 female not ripe, and 1 female spent; of the 8 males, 3 were ripe, 2 partly spent, and 1 entirely spent; this last was badly mutilated and covered with sores. Net C contained 12 fish, all males, 10 evidently going up and 2 apparently going down; all of those going up were about ripe; none had spawned and none showed any mutilations. Net D at the outlet contained 5 males and 1 female, all going up; the males were all quite solid, but the female was ripe. Only one of the 42 fish taken in the nets to-day was noticeably sore, and one other showed the ventral fins very slightly worn.

September 2: Net B contained 8 fish, viz, 4 ripe males going down, 1 ripe male going up, 1 nearly spent, sore male going up, and 2 solid females going up. Net C contained 6 fish, viz, 3 ripe males and 1 ripe female going up, and 1 ripe male and 1 partly spent, sore male going down. Net D contained 12 fish, 7 males and 5 females, all going up, except 1 ripe male which was apparently going down, but it is likely that it, too, was really caught going up and turned in the net. Four of the males were ripe, while the remaining 8 fish were scarcely or not at all ripe. There were no sores or mutilations of any kind.

September 3: Net B contained 6 fish, 4 of which were going up. Three of these were scarcely ripe males, the other an unripe female. The 2 going down, a male and a female, were both spent fish, both dead and merely lodged against the net. Net C had 9 fish, 8 evidently going up, and 1 turned so as to appear as if going down. Seven of these were ripe males, the other 2 scarcely ripe females. Net D contained 16 fish, all going up. Of these, 5 males and 2 females were solid, and 5 males and 4 females were ripe. These 16 fish were all in perfect condition, as were all those taken in nets B and C, except the 2 spent fish taken in B, which were both considerably mutilated. Net C was to-day taken up and reset in the outlet of Alturas Lake a few rods below the lake.

Mr. Edward G. Burnet and party, of Corral, Idaho, who spent a few days camping at Alturas Lake, caught about 80 redfish, one of them a large female with nearly the whole tail worn off. About a third of the catch were females.

September 4: Net B contained 5 fish, 2 ripe males and 1 nearly dead male going up, and 1 nearly spent female and 1 dead female going down, the dead fish being merely lodged against the net. Net D had 12 fish, 6 males and 6 females, all going up. Only 3 of the males and 1 of the females were ripe. All were in excellent condition and were salted down by Mr. Burnet, to whom we gave them.

September 5: Net B had 17 fish, 9 going up and 8 down. Of those going up, there were 3 ripe males, 1 scarcely ripe male, 1 partly spent and sore male, and 1 dead spent male; those going down were 1 dead spent male, 4 nearly dead males, 1 dead spent female, and 2 spent males. Nearly all of these fish were more or less mutilated and covered with sores. Net D contained 6 fish, 2 nearly ripe males and 3 ripe females going up and 1 nearly dead spent male going down.

September 6: Net D contained 5 fish, 3 solid females and 2 ripe males, all going up and all in good condition. The record of this date for Net B was unfortunately lost.

September 7: Net B had 8 fish, all males; one ripe male going up and 7 spent males going down; 5 of these were dead or nearly so and were simply lodged against the net; all of the 7 were covered with sores and had the fins badly frayed. Net D had 2 nearly dead males lodged against the upper side, both spent and sore, and 1 ripe male gilled from the lower side.

To-day a careful count was made of all the redfish in Alturas Inlet and the total number found was about 1,000. The lower $1\frac{1}{4}$ miles of the creek had about 300 fish; the next $1\frac{1}{2}$ miles contained about twice as many, while the remaining portion of the stream contained only about 100 fish. Those in the lower portion were mostly in excellent condition; most of them were in the deeper holes and only a few were seen spawning. These are pretty certainly the fish which have last come into the creek. Those in the middle portion of the creek were either out in shallow water spawning or were spent fish which had retired to the pools. Fully one-half, perhaps two-thirds, of the entire number were plainly seen to be mutilated. The fish in the upper part of the stream were nearly all done spawning and many of them were weak and dying and drifting down with the current. Scarcely a fish could be seen here that was free of mutilations and sores.

September 8: Net B had 2 spent males lodged against the upper side; both were covered with mutilations. Net D contained 12 fish, 7 going up and 5 down; of those going up 5 were females and 2 males, all solid; those going down were 2 dead males, 3 nearly dead spent males, and 1 ripe female which had probably turned in the net; the 5 males going down were much mutilated. Later in the day a 28-inch male weighing $6\frac{1}{2}$ pounds was taken in net B; this fish was ripe and in perfect condition, except a slight mutilation on the branchiostegals.

September 9: Net B had 10 fish, 6 going up and 4 down; those going up were 2 ripe females and 4 nearly spent males; those going down were 3 very sore spent males, lodged against the net and 1 almost spent female.

Net D contained 10 fish, 7 going up and 3 down. Those going up were 3 males and 4 females, all ripe and in perfect condition; the 3 going down were 1 dead male and 1 dead female lodged, and 1 nearly dead female, all spent and much worn. Net D was taken up to-day.

September 11: Net B contained 16 fish; 1 ripe male and 1 ripe female going up; 13 males and 1 female, all spent and sore, going down and merely lodged against the net except 2 males which were gilled. These were all very badly worn, some of them having the caudal almost entirely worn away.

September 12: Net B had 13 fish, 12 males and 1 female, all going down; 7 were dead and lodged, and all but 4 of the 13 were badly mutilated. In the evening this net was again examined and 8 fish found, 5 of them gilled from the upper side and 3 merely lodged; 4 were in pretty good condition but spent; all of the other 4 were spent and much worn, 2 being dead and the others nearly so. An inspection of the last 2 miles of the inlet to-day showed a great decrease in the number of redfish, and that nearly all that are left are more or less covered with sores.

September 13: The creek has risen about 2 feet on account of heavy rains. The nets were not relieved of their catch, but 8 or 10 fish could be seen lodged against Net B.

September 14: Net B had 14 fish lodged against it this morning, 12 males and 2 females; 3 or 4 of the males were well gilled, while all the others were gilled only slightly or not at all; all but 3 were dead and all but 2 or 3 were badly worn. To-day the entire creek was examined again, and the total number of live fish found was about 263, of which 26 were between the lake and our camp, 137 in the next $1\frac{1}{2}$ miles, and about 100 still farther up. The great majority seemed to be males; indeed, of the 137 seen by Mr. Scofield only 18 were believed to be females. Spawning appeared to be practically at an end; nearly all the fish were badly mutilated; nearly all were lying quietly in the deeper, more quiet portions of the stream or were being slowly carried down by the current. A dozen dead ones, all males, were seen, and it is evident that many others were nearly dead. On September 7 the total number seen was about 1,000; there was, therefore, a decrease of nearly 750 fish in a week. A few days more and all will probably have died.

September 15: Net B contained 1 large redfish and 4 small ones; the large one was a male in fine condition and only partly spent. All the small ones were males, all spent and sore, 1 dead and lodged against the net, the other 3 gilled from above. Net D at the mouth of the inlet was put in again to-day.

September 15: Net B had 3 dead fish lodged against it.

September 16: Net B had 9 fish on upper side, 7 males and 2 females; all were spent and 5 were dead. Net D contained nothing. The entire inlet was inspected again to-day, and only 213 fish found. The lower 2 miles contained 105 fish, and all the rest of the creek 108; 14 dead ones were seen. Of the 108, only 13 appeared to be females. The fish were nearly all badly mutilated. All were apparently done spawning and many were dying.

September 17: Net B had 10 fish lodged and 2 gilled from upper side; 11 were males and 1 a female, all spent, all with numerous sores and mutilations, and 9 dead. Net D had 1 dead spent female gilled from above. All its fins were frayed out. This net has now been in two nights, and not a fish has been caught going up. This morning Mr. Fred Ashley, who was camped near us, saw 2 large male redfish in Alturas Lake swimming along the west shore. I visited the place in the afternoon, and saw 1 large redfish. He was swimming along near shore in shallow water. After going up a few rods, he would turn around and swim down the shore about the same distance, only to return up the shore again. This fish was in excellent condition, and is the only redfish I have ever seen in any of these lakes.

September 18: Net B had 7 fish, 6 males and 1 female, all lodged except 2, which were gilled going down. All were spent and mutilated, and all but 3 males. Net D contained nothing. To-day camp was moved to Alturas Creek opposite Pettit Lake.

September 22: Net B, which had not been visited since 18th instant, contained 17 fish, all lodged or slightly gilled on the upper side. There were 14 males and 3 females, all dead but 1 male and 2 females. All were spent, and all very much mutilated except 1 live male and 1 live female. Net D contained nothing. An inspection of about $1\frac{1}{2}$ miles of the lower part of the creek showed only 5 live fish, but several dead ones were seen. The spawning season is evidently wholly over, and only a very few weak, dying fish are left.

This date, September 22, is that of our last inspection of Alturas Lake and Inlet. Mr. F. C. Parks, however, visited them at various times in October, but saw no redfish.

Tho foregoing extracts from our field notes have been given in order that the following discussions of the various more important questions in the life-history of the redfish may be more readily intelligible.

1. Do the small redfish come up from the sea?

This question can not, in the light of our present information, be definitely answered one way or the other. They were already in Alturas Lake July 20, when our net was first placed in the outlet, and it is extremely improbable that any entered the lake from below subsequent to that date. Whether they had really come up from the sea and entered the lake prior to July 20 can not be positively asserted. The evidence that they are anadromous rests chiefly upon analogy and their apparent specific identity with the large form. No specimens of the small redfish have ever been obtained or seen by any collector in the Columbia Basin below these lakes; indeed, so far as can be dotermined by an examination of the literature upon the matter, the small redfish has never been seen by anyone except in certain lakes or their inlets. The list of lakes in which it is known to occur is as follows: Chiloweyuck Lake (north latitude 49°), near Fraser River; Nicola, François, Fraser, and Okanogan lakes, the first three tributary to the Fraser, the last to the Columbia (Dr. Dawson); Alturas and Big Payette lakes in Idaho; Wallowa Lake in Oregon; Lake Washington at Seattle; Stuart and Shushwap lakes in British Columbia. It was seen many years ago at Wallowa Lake by Major Bendire, who has always maintained that it is an anadromous fish. It probably occurs also in Pettit, Redfish, and Stanley lakes, in Idaho, and possibly elsewhere.

It should be borne in mind, however, that very little search has been made for it in the Columbia by ichthyologists and it might well have escaped their observation. That it has never been detected by the fishermen is difficult of explanation, unless it be that the small size, color, and general appearance of the fish caused it to be mistaken for the black-spotted trout; for, like the large form, these small redfish are more or less red only at spawning time. Even during the spawning season many of the females and some of the males are not red at all and might very easily be mistaken for trout by anyone unacquainted with the technical characters separating the species. In fact, several females taken in Alturas Inlet were pronounced to bo trout by more than one person to whom they were shown.

While we may be as certain as anyone can be, in the absence of actual proof, that the small redfish is anadromous, the question is still an open one and can be settled only by careful examination of the Columbia and its tributary streams below the lakes during the period when these fish are supposed to be running.

2. Do the large redfish ascend to these lakes from the sea?

This question can be answered positively in the affirmative. The evidence that this form is anadromous may be regarded as amounting to absolute proof.

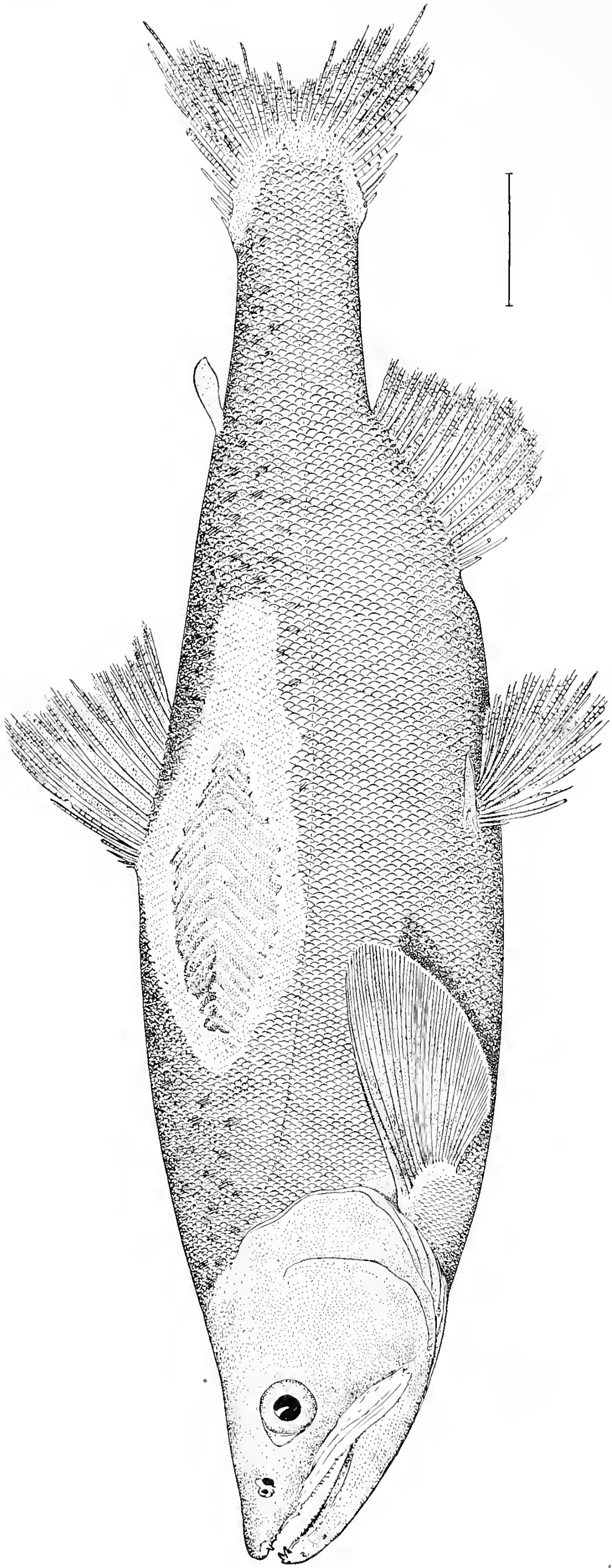
They are caught every year in great numbers in the lower Columbia and rank second in commercial value only to the chinook salmon. But their movements after passing the fishing-grounds of the lower Columbia are not so easily traced. They have been obtained, however, by Major Bendire and also by Dr. Gilbert in the outlet of Wallowa Lake in Oregon. No naturalists have ever reported specimens from any place in Idaho except in the lakes or their inlets.

Mr. F. C. Parks has frequently seen them in Alturas Outlet and in Salmon River, near by, and others have reported seeing them at various places in Salmon River, particularly in the vicinity of Challis. But no large redfish were seen by us below the lakes, the only places where we saw them being in the inlets to Pettit, Alturas, and Big Payette lakes and in Alturas Lake.

3. What is the spawning period of the redfish at the Idaho lakes?

We do not yet know tho actual time of arrival at any of these lakes, but more definite data are at hand regarding their time of entering the inlets. As previously stated, the redfish were already in Alturas Lake prior to July 20, began running up the inlet on the night of July 23, and continued to do so until about September 10. The heaviest run was during the time between August 7 and September 1, although a good many came after that date. Ripe fish were found as early as August 2, and ripe, unspent fish were caught as late as September 11. The height of the spawning season, however, extended from August 25 to September 5.

On September 12, 1894, there were 128 redfish in Alturas Inlet and some of them were still spawning. No live fish were seen in Pettit Lake Inlet September 13, 1894, and only 2 redfish were seen there in 1895. Both were the large form, one a ripe female caught August 14, the other August 22.



BREEDING MALE REDFISH (*Oncorhynchus nerka*), small form.

Drawn from a specimen $11\frac{3}{8}$ inches long, showing mutilations received on spawning grounds. Alturas Creek, Idaho, September 17, 1895.

At Big Payette Lake, September 27, 1894, I saw several small dead redfish and 6 large live ones. They were nearly all spent fish, and the spawning season there was practically over. In 1895 the first redfish at Big Payette Lake were seen by Mr. Williams on September 3. They were in a pool in the inlet about 4 miles above the lake. He saw 3 large ones and 6 small ones. A short distance above another large one was seen. On September 5 this place was again visited by Mr. Williams, and 3 large redfish and 9 small ones were caught. The 3 large ones were all ripe males. Of the small ones no others were seen. On September 15, 3 more large ones were noticed near the same place, one of the 3 being a female. On September 23 the inlet was again visited and 2 large redfish seen. They were covered with sores and appeared very weak.

In a letter received by Mr. Williams from Mr. McCall since leaving the lake, Mr. McCall states that he caught 4 large redfish in the inlet October 8, and that they were still spawning and in good condition. This confirms the belief expressed in the report of my visit to this lake in 1894, viz, that the spawning season here is later than at Alturas Lake.

Prof. O. B. Johnson found the small form spawning in Lake Washington near the last of November, 1888, and on October 8, 1889. Dr. Dawson found them spawning in the first week of September, 1877, in the small streams on the west side of Okanogan Lake, and again in the same streams on September 16 and 17, 1890, particularly in the one known as Bear River. In a letter to Dr. Bean, Dr. Dawson says:

> A great number of little salmon-like fish, apparently running up to spawn. It is singular that though they have evidently been long in the stream (from the livid red color of many of them, their frayed fins and tails, with white fungoid growth in places) they have not got farther up the river, which offers no particular impediment to their ascent. They can not all have spawned, as many still hold spawn and milt. Indians say they all die in the stream and do not return to the lake. Many were dead along the shores, and the crows had collected in great numbers in the vicinity. This was within a quarter of a mile or less from the mouth of the river on the lake.—*Forest and Stream*, July 9, 1891.

Dr. Kennerly says that they disappeared suddenly about September 1, at Chiloweyuck Lake. He first saw them in a small stream tributary to this lake, and in vast numbers. On August 17 he and his companions caught 180 with hook and line. About August 10 they appeared at the mouths of all the small streams emptying into the lake in such numbers that they could be caught with the hands.

4. Where and how are the mutilations received?

The sores, frayed-out fins, and other mutilations which have been noticed upon the chinook salmon and redfish by everyone who has ever seen these fishes upon their spawning-grounds have been regarded by all as being due chiefly, if not wholly, to the injuries incident to the long journey from the sea. Coming to these Idaho lakes from the sea requires a journey of more than 1,000 miles, and it is, in large part, through swift and turbulent waters and up dangerous rapids, cascades, and waterfalls, against whose ragged and jagged rocky walls and bed the fish would often be thrown by the seething currents. That they could make this long and perilous journey unscathed could scarcely be believed.

In the shorter coastal streams of Oregon, Washington, British Columbia, and northward, the same mutilations have been observed and have usually, without sufficient reason, been attributed to the same cause. Until now it has therefore been generally held that the injuries are received by the fish while en route to the spawning-grounds. Our continuous series of observations at Alturas Lake during the entire period of the breeding season shows, however, that this is not the true explanation. Among the hundreds of redfish which we examined as they came up into Alturas Inlet from the lake, not one possessed any sores or had the fins frayed out in the least; every one was perfect in every way, so far as mutilations were concerned. Not only were all of those caught on the gill nets as they came up from the lake free of sores, but no sores were seen on any of the fish in the creek until some time after the spawning had begun. The first fish were seen July 24, but not until August 10 were any mutilated ones observed, and then only 3 out of 84 examined showed any considerable mutilations.

In marked contrast with this perfect condition of the fish as they arrive upon their spawning-grounds is that observed toward the close of the spawning season, when scarcely a fish can be found whose fins are not badly frayed and upon whose body are not one or more large sores. The nature of these mutilations is well shown in plate 72.

The manner in which the mutilations are really received was readily determined by watching the fish while spawning. The spawning-beds are usually in very shallow water, often only a few inches deep. These beds are of fine granite gravel and sand. There is more or less definite pairing off of the fishes, and each pair usually does all its spawning on a certain area, which may be called the nest. The gravel and sand of this area are moved about and piled up somewhat in heaps or rows as the fish scoop out shallow depressions in the bed; this scooping or moving of the gravel is done as

the fish swims upstream over the bed with a rapid quivering motion of the body; during this act the body is always inclined to one side and the gravel is chiefly pushed in the other direction; after swimming across the nest in this way, the fish circles around downstream and returns to the bed to repeat the same process again and again, and keeps it up for several days. During all this time the male follows closely behind the female, sometimes quivering and plowing through the sand and gravel in the same way and thus receiving mutilations of the same character. Often the back of the fish is turned against the gravel and becomes worn. On each spawning-bed are usually several supernumerary males, and among them and the paired males there is much chasing about and some fighting, which results in still further mutilations. It may therefore be positively stated that the sores and mutilations seen on the redfish at the Idaho spawning-grounds are practically all received after the spawning season begins.

5. *What becomes of the redfish after they have finished spawning?*

Our observations made at Alturas and Payette lakes in 1894 and 1895, and particularly those at Alturas Lake in 1895, which have already been given with considerable detail, leave no doubt as to the answer to this question. The redfish which spawn in the inlets to the Idaho lakes never return to the sea, but all die at the close of the spawning season. The evidence is conclusive. On September 6 there were about 1,000 redfish in Alturas Inlet. By September 14 the number had been reduced to about 263, a net decrease of nearly 750 in one week. Two days later, September 16, only 213 fish were found in the entire stream, and on September 22 there were probably not over 25 fish left. That this decrease was caused by the death of the fish and not by their running downstream into the lake is certain. The gill nets near the mouth of the inlet would have prevented them from returning to the lake had they desired to do so. But the daily inspection of the nets showed that there was little if any tendency on the part of the fish to return to the lake. The fish caught in the nets from above were usually dead or dying fish which were too weak to resist the strength of the current and were consequently carried against the nets. After the spawning season was well advanced, dead fish could be found any day along the stream; and the seriously mutilated condition of practically all the fish near the close of the spawning precludes the probability of their recovery.

6. The question as to the relationship of what I have designated as the large and small forms of the redfish is an interesting one and not easy to settle. The large form has been described as new no fewer than eight times, and the small one twice. The following is a list of the names, in order of date, which have been applied to the two forms:

Large form:
- *Salmo nerka* Walbaum, 1792. Kamchatka.
- *Salmo lycaodon* Pallas, 1811. Kamchatka.
- *Salmo paucidens* Richardson, 1836. Columbia River.
- *Salmo tapdisma* Cuvier & Valenciennes, 1848. Kamchatka.
- *Salmo arabatsch* Cuvier & Valenciennes, 1848. Kamchatka.
- *Salmo melampterus* Cuvier & Valenciennes, 1848. Kamchatka.
- *Salmo cooperi* Suckley, 1861. Okanogan River.
- *Salmo richardi* Suckley, 1861. Fraser and Skagit rivers.

Small form:
- *Salmo kennerlyi* Suckley, 1861. Chiloweyuck Lake.
- *Salmo warreni* Suckley, 1861. Fraser River.

In 1862 Dr. Gill made the small form the type of a new genus, which he called *Hypsifario*, the "compressed body and projecting snout" being the characters assigned.

Jordan & Gilbert have regarded the small redfish as being specifically identical with the large form. In 1891 Dr. Bean examined a number of specimens of the little redfish which the National Museum had received from Lake Washington, at Seattle, where they were obtained by Prof. O. B. Johnson, of the State University of Washington. An examination of these specimens, together with others from British Columbia, and the notes of Professor Johnson and Dr. Dawson, of Ottawa, convinced Dr. Bean that the little redfish is a landlocked form and should rank as a subspecies, standing as *Oncorhynchus nerka kennerlyi*. The differential characters which Dr. Bean regarded as of value were (1) the difference in the number of gillrakers, and (2) the difference in the size of the fins. He thought that the smaller form had only about 30 gillrakers, while the larger had about 40.

An examination of a large series of specimens of each form shows no difference in the gillrakers and none of importance in the fins, as may be seen from the following table. Indeed, except in the matter of size, there seem to be no structural differences of any value whatever. In color the large ones are, at spawning time, usually a brighter and more uniform red, the females being quite as red

as the males. The head in both sexes is pale olive in color. In the small form some individuals, usually males, are quite as red as the large ones, but the small ones are in most cases noticeably darker and less red, the head less olive, and the black spots on the back are more numerous and better defined.

The small form is a much trimmer fish in general appearance—the snout is relatively shorter and the eye larger. At the breeding season the snout in the males of the large form becomes greatly distorted; in the small males the distortion is not so great; in the large females it is rarely noticeable, while no change at all seems to take place in the small females. The constant and uniform difference in size of the two forms is a matter of great interest. The individuals of the small form vary but slightly in length and scarcely at all in weight. The length is about a foot, never varying more than 2 inches either way, and the weight is half a pound, with astonishing constancy. Hundreds of individuals were weighed by us, and, except near the end of the spawning season, the weight was always half a pound each. It made no difference how many fish we weighed in a bunch, the weight in pounds would invariably be half the number of fish weighed. At the beginning of the season, when none had yet spawned, the weight was usually a trifle strong, while at the end it usually fell a trifle short of the half pound, the difference being, of course, the loss due to spawning and worn-off fins.

The individuals of the large form which were examined at the Idaho lakes vary from 22 to 27 inches in total length and from 5 to 6 pounds. Spent fish weigh considerably less. In Alaska and elsewhere individuals of considerably greater weight are frequent. The meaning of this uniform difference in size is a matter not easy to explain, unless it be shown that they are really different species. Until further observations are made, it seems useless to offer any explanation.

Comparative measurements and other data regarding a large number of specimens of the redfish are given in the following table:

LARGE FORM.

Tag No.	Length.	Sex.	Head.	Depth.	Eye.	Anal rays.	Branchio-stegals.	Height of dorsal in head.	Condition.
1	21	Male......	$3\frac{1}{3}$	$4\frac{1}{5}$	$7\frac{2}{3}$	15	13+13 L.	$2\frac{1}{5}$	
2	....	Male......	....	....	$7\frac{1}{2}$	....	14+14 L.	....	Only a head.
3	22	Female ...	$4\frac{1}{5}$	5	$6\frac{1}{2}$	14	13+14	2	
45	20	Female ...	$4\frac{2}{5}$	$5\frac{1}{3}$	6	14	13+14	$1\frac{4}{7}$	Caudal and ventral badly frayed, spent.
212	$23\frac{1}{2}$	Male......	$3\frac{2}{3}$	$4\frac{1}{6}$	$7\frac{1}{3}$	14	13+13 L.	$2\frac{1}{2}$	
213	21	Male......	$3\frac{3}{5}$	4	$6\frac{3}{4}$	14	13+13 L.	$2\frac{1}{5}$	
214	23	Male......	$3\frac{1}{3}$	4	7	14	15+14 L.	$2\frac{1}{2}$	
215	27	....	$4\frac{1}{5}$	5	7	14	13+14 L.	2	
216	25	Male......	$3\frac{1}{5}$	$4\frac{1}{2}$	$7\frac{1}{4}$	14	14+13 L.	$2\frac{1}{3}$	

SMALL FORM.

	Length.	Sex.	Head.	Depth.	Eye.	Anal rays.	Branchio-stegals.	Height of dorsal in head.	Condition.
These 14 weighed just 7 pounds.	$11\frac{3}{4}$	Male......	$3\frac{4}{5}$	$4\frac{1}{2}$	5	14	13+14 L.	2	Caudal and base of ventral worn, one ventral gone, spent.
	$11\frac{3}{4}$	Male......	$3\frac{4}{5}$	4	$5\frac{1}{2}$	14	13+13 L.	2	C., A., D., and V. sore, back sore, spent.
	$12\frac{1}{4}$	Male......	$3\frac{2}{3}$	$4\frac{1}{3}$	$5\frac{1}{2}$	14	12+13 L.	$1\frac{9}{10}$	Solid, perfect, very little spent.
	$11\frac{1}{2}$	Male......	$3\frac{4}{5}$	4	$4\frac{1}{2}$	13	14+13 L.	$1\frac{4}{5}$	Head bitten, ripe.
	$11\frac{1}{4}$	Male......	$3\frac{4}{5}$	$4\frac{1}{3}$	$5\frac{1}{5}$	Worn.	13+14 L.	2	C., A., D., and V. all badly frayed, jaws sore, spent, adipose fin gone.
	12	Male......	4	$4\frac{1}{2}$	5	14	13+13 L.	$1\frac{9}{10}$	Solid, no sores; ripe, but not spent.
	$12\frac{1}{4}$	Male......	$3\frac{4}{5}$	$4\frac{1}{3}$	5	14	13+14 L.	$1\frac{9}{10}$	Spent, no sores; ripe.
	$11\frac{1}{2}$	Male......	$3\frac{1}{2}$	4	5	14	13+14 L.	2	Dorsal frayed, spent.
	$11\frac{3}{4}$	Female ...	$4\frac{1}{3}$	$4\frac{1}{3}$	$5\frac{1}{4}$	13	13+14 L.	$1\frac{2}{3}$	Almost ripe, solid, perfect.
	$12\frac{1}{4}$	Female ...	$4\frac{1}{8}$	$4\frac{1}{8}$	$4\frac{4}{5}$	14	13+14 L.	$1\frac{4}{5}$	Ripe, solid, perfect; very dark.
	$11\frac{1}{2}$	Female ...	$4\frac{1}{4}$	4	$4\frac{2}{3}$	13	13+14 L.	$1\frac{3}{4}$	Scarcely ripe, solid, perfect; very dark.
	$11\frac{1}{2}$	Female ...	$4\frac{1}{5}$	$4\frac{1}{5}$	5	14	13+14 L.	$1\frac{1}{5}$	Nearly ripe, solid, perfect; very dark.
	$11\frac{3}{4}$	Female ...	$4\frac{1}{4}$	$4\frac{1}{8}$	$4\frac{1}{2}$	15	13+12 L.	$1\frac{3}{4}$	Ripe, solid, perfect.
	$11\frac{1}{2}$	Female ...	$4\frac{1}{5}$	$4\frac{1}{2}$	$4\frac{1}{2}$	14	13+14 L.	$1\frac{3}{4}$	Scarcely ripe, solid, perfect.

SMALL FORM—Continued.

Tag No.	Length.	Sex.	Head.	Depth.	Eye.	Anal rays.	Branchiostegals.	Height of dorsal in head.	Condition.
4	11	Male......	4	4	5	15	12+13	1 7/8	C., A., D., V., P., and snout badly worn.
5	11	Female ...	4 1/3	4 1/3	5	13	13+14	1 2/3	C. badly worn.
6	12	Male......	3 2/3	3 2/3	5	13	14+14	2	C. and jaws badly worn.
7	11 1/2	Male......	4	3 3/4	5	13	13+13 L.	2	C. and jaws slightly worn.
8	10 1/2	Female ...	4 1/2	4 1/2	4 1/3	13	13+13	1 3/4	C. badly worn.
9	11 1/4	Male......	3 2/3	4	5	14	13+14	1 7/8	C., A., D., and V. badly worn.
10	12	Male......	3 3/5	3 3/5	5 1/2	14	14+14	2	C. slightly worn.
11	11 1/4	Female ...	3 4/5	3 1/5	4 3/4	14	13+13	1 4/5	C. and jaws slightly worn.
12	11 3/4	Male......	3 4/5	3 1/5	5 1/2	14	14+15	2 1/5	Perfect.
13	10 3/4	Female ...	3 2/3	3 3/4	5	15	14+14	2	C. and V. badly worn.
14	11 1/2	Female ...	4	4 1/4	4 1/2	14	14+14	1 3/4	C. slightly worn.
15	11	Female ...	4 1/4	4 1/4	4 2/3	14	14+14	2	Perfect.
16	10 3/4	Female (?)	4 1/6	4 1/2	4 3/4	14	15+14	1 3/4	Do.
17	11 1/4	Female ...	4	4 1/2	4 1/2	14	13+14	1 3/4	C. badly frayed.
18	11 3/4	Male......	4	4	5	14	12+12	2	C. and D. frayed.
19	12 1/4	Female ...	4 1/4	4 3/4	4 2/3	13	13+14	1 3/4	C. badly worn.
20	11 1/2	Female ...	4	5	5 1/3	14	13+13	1 2/3	C. gone, A. worn.
21	10 1/2	Male......	3 3/4	4	4 3/4	14	13+14	2	D. and C. badly frayed
22	10 1/2	Female ...	4	4 1/2	4 2/3	14	14+14	2	C. almost worn off.
48	11	Female ...	4	4	4 1/2	15	14+13	1 4/5	Ripe, perfect.
49	11 1/2	Male......	3 5/6	4 1/5	5 1/3	15	14+13	1 4/5	Do.
50	11 1/4	Female ...	4	4	5	15	13+14 L.	1 4/5	Do.
51	12	Male......	3 2/3	3 2/3	5 1/2	15	14+14 L.	2	Do.
52	11 1/2	Male......	3 3/4	4 1/4	5 1/4	15	13+13 L.	1 4/5	C., D., V., worn, spent.
53	12	Male......	3 5/6	4	5 2/3	15	13+13 L.	1 4/5	Ripe, perfect.
54	11 1/2	Male......	3 3/4	4 1/4	5 1/4	15	13+13 L.	1 1/5	C., D., and V. worn, spent.
55	12	Male......	4	4 1/4	5 1/2	14	14+14 L.	1 7/8	Perfect.
56	11 1/2	Male......	3 3/4	3 3/4	4 3/4	14	14+15 L.	2	C. slightly worn, ripe.
57	11 1/2	Male......	3 7/8	3 3/4	5	14	14+15 L.	2	Not ripe, perfect.
58	11 1/4	Female ...	4 1/3	4 1/2	5	14	13+13	1 3/5	Ripe, perfect.
59	11 3/4	Male......	4	4	5 1/2	14	13+14	2	Do.
60	11	Female ...	4 1/5	4 3/5	5	14	13+14	1 3/5	Do.
61	12	Male......	3 4/5	4	5 3/4	14	13+14 L.	1 4/5	Ripe, caudal slightly worn
62	11 1/2	Female ...	4 1/3	4 1/2	5	14	14+14 L.	2	Ripe, perfect.
63	11 3/4	Male......	4	4 1/4	5 1/3	14	14+13 L.	1 3/4	Do.
64	11 1/2	Male......	4	4	5 1/2	15	13+13 L.	1 5/6	Do.
65	11 1/2	Female ...	4 2/3	4 1/4	5	15	14+15 L.	1 3/4	Do.
66	11 3/4	Male......	3 5/6	3 5/6	6	14	13+13 L.	1 7/8	Do.
67	12	Male......	3 5/6	4 1/4	5 3/4	14	14+15	1 5/6	Do.
68	12	Male......	4	4	5	14	13+13 L.	2	Ripe, perfect, opercular flap gone.
69	11 3/4	Male......	4	4 1/3	5 1/3	14	13+14 L.	1 2/3	Ripe, perfect.
70	12 1/2	Female ...	4 2/5	5	5 1/2	14	14+15	1 1/2	Do.
71	11 3/4	Female ...	4 1/2	4 1/2	5	14	13+14	1 2/3	Do.
72	11 3/4	Male......	4	4	5 1/3	14	14+13	2	Do.
73	11 3/4	Male......	4	3 2/3	6	14	13+14	1 4/5	Do.
74	11 3/4	Female ...	4 1/3	4 1/3	5	15	14+15	1 3/4	Do.
75	11 1/2	Male......	3 5/6	3 5/6	5 1/3	15	13+13 L.	1 4/5	C. and D. worn slightly, spent.
76	10 3/4	Female ...	4 1/3	4 1/5	4 1/3	14	13+13	1 1/5	C. frayed, ripe.
77	11 1/2	Female ...	4 1/3	4 2/3	5	14	13+14	1 5/6	Ripe, perfect.
78	11 1/2	Female ...	4	4 1/2	5	14	14+14	1 2/3	Do.
79	11 1/2	Female ...	4	4	5	14	14+15	1 3/4	Spent, perfect.
80	11 1/2	Male......	3 2/3	3 7/8	5 1/3	14	14+15 L.	2	C., D., V. frayed; jaws, snout, and back worn bare, spent.

SMALL FORM—Continued.

Tag No.	Length.	Sex.	Head.	Depth.	Eye.	Anal rays.	Branchiostegals.	Height of dorsal in head.	Condition.
81	$10\frac{1}{4}$	Female ...	$4\frac{1}{4}$	$4\frac{3}{5}$	5	14	14+14 L.	$1\frac{2}{3}$	C. and D. frayed, spent.
82	$10\frac{1}{4}$	Female ...	$4\frac{1}{6}$	5	$4\frac{2}{3}$	15	13+14 L.	2	C. gone; A., D., V., and snout, and P. badly frayed.
83	$10\frac{1}{4}$	Female ...	4	5	5	14	13+14 L.	$1\frac{4}{5}$	C. gone; A., D., V., and snout, and P. frayed.
84	$10\frac{3}{4}$	Female ...	4	4	5	14	12+12 L.	$1\frac{3}{4}$	C. slightly worn.
85	11	Female ...	$4\frac{1}{3}$	$4\frac{2}{3}$	$4\frac{3}{5}$	15	13+13 L.	$1\frac{3}{5}$	Perfect.
86	12	Male......	$3\frac{2}{3}$	$3\frac{2}{3}$	$5\frac{3}{5}$	14	13+14 L.	2	Do.
87	$11\frac{3}{4}$	Female ...	4	$4\frac{2}{3}$	$4\frac{3}{5}$	15	15+14 L.	2	Perfect, ripe.
88	$11\frac{1}{4}$	Female ...	4	$4\frac{1}{3}$	$4\frac{1}{3}$	14	14+15 L.	$1\frac{4}{5}$	Do.
89	12	Male......	4	$4\frac{1}{4}$	5	14	13+13 L.	$1\frac{2}{3}$	Do.
90	$11\frac{1}{2}$	Male......	$3\frac{4}{5}$	4	$4\frac{4}{5}$	15	14+14 L.	2	Do.
99	$11\frac{1}{2}$	Male......	4	4	5	14	14+14 L.	2	Perfect, not ripe.
100	$12\frac{1}{2}$	Female ...	$4\frac{1}{3}$	$4\frac{2}{3}$	5	14	14+15	$1\frac{4}{5}$	Perfect, ripe.
111	$11\frac{1}{4}$	Female ...	4	4	5	14	14+14 L.	2	Do.
112	$11\frac{1}{4}$	Male......	$3\frac{3}{4}$	4	$6\frac{1}{2}$	14	15+15 L.	2	Perfect, not ripe.
185	11	Male......	4	$4\frac{1}{4}$	$4\frac{1}{2}$	15	13+14 L.	2	Perfect; parasites on gills.
186	$10\frac{3}{4}$	Male......	4	4	$4\frac{1}{3}$	14	13+14	$1\frac{3}{4}$	Do.
187	$10\frac{1}{2}$	Male......	4	$3\frac{4}{5}$	$4\frac{1}{4}$	14	12+12	$1\frac{3}{4}$	Do.
188	$11\frac{1}{4}$	Male......	$4\frac{2}{5}$	$4\frac{2}{5}$	$4\frac{1}{5}$	14	12+13 L.	$1\frac{9}{10}$	Perfect, not ripe; parasites on gills.
189	$11\frac{1}{4}$	Female ...	$4\frac{1}{2}$	$4\frac{1}{2}$	$4\frac{1}{2}$	14	13+13 L.	$1\frac{9}{10}$	Do.
190	$10\frac{1}{4}$	Male......	4	$4\frac{1}{6}$	$4\frac{1}{3}$	14	13+14 L.	$1\frac{3}{4}$	Perfect, ripe.
191	$10\frac{3}{4}$	Male......	4	4	5	14	13+14 L.	$1\frac{3}{4}$	Do.
192	$11\frac{1}{4}$	Male......	$4\frac{1}{8}$	4	5	15	12+13 L.	$1\frac{4}{5}$	Perfect, not ripe.
193	$11\frac{1}{4}$	Male......	4	4	5	15	13+13 L.	$1\frac{7}{8}$	Do.
194	$11\frac{1}{4}$	Male......	4	4	5	15	13+13 L.	$1\frac{9}{10}$	Perfect, not ripe; parasites on gills.
220	$11\frac{3}{4}$	Male......	4	$3\frac{7}{8}$	5	14	14+14	$1\frac{3}{4}$	Perfect, ripe.
221	$11\frac{1}{2}$	Male......	4	4	5	14	12+12	$1\frac{1}{5}$	Do.
222	$11\frac{3}{4}$	Female ...	$4\frac{2}{5}$	$4\frac{1}{5}$	$4\frac{2}{3}$	14	13+13	$1\frac{3}{4}$	Do.
223	12	Male......	$3\frac{3}{4}$	$3\frac{3}{4}$	$5\frac{2}{3}$	14	13+12	$1\frac{3}{5}$	Do.
224	$11\frac{3}{4}$	Male......	4	4	5	14	13+13	2	Do.
225	$11\frac{1}{2}$	Male......	$3\frac{4}{5}$	4	5	14	13+13	2	C. and D. slightly worn, ripe.
226	$11\frac{1}{2}$	Male......	$3\frac{4}{5}$	$3\frac{1}{2}$	5	14	12+13	$1\frac{5}{6}$	Perfect, ripe.
227	12	Male......	4	4	5	14	13+14	$1\frac{4}{5}$	Do.
228	12	Male......	$3\frac{3}{5}$	4	5	14	13+13	$1\frac{5}{6}$	Do.
229	12	Female ...	$4\frac{1}{2}$	$4\frac{1}{3}$	$4\frac{2}{3}$	14	13+13	2	Do.
230	$11\frac{1}{4}$	Female ...	$4\frac{1}{4}$	$4\frac{1}{2}$	$4\frac{2}{3}$	15	12+13	$1\frac{3}{4}$	Do.
231	$11\frac{1}{2}$	Male......	$3\frac{3}{4}$	$3\frac{3}{4}$	5	14	13+13	$1\frac{5}{6}$	Do.
232	$11\frac{3}{4}$	Male......	$3\frac{4}{5}$	$3\frac{4}{5}$	5	14	14+14	2	Do.
233	$11\frac{1}{2}$	Female ...	$4\frac{1}{2}$	$4\frac{1}{5}$	$4\frac{1}{3}$	14	13+14	$1\frac{4}{5}$	Do.
234	$11\frac{1}{2}$	Male......	$3\frac{4}{5}$	$3\frac{4}{5}$	5	14	13+14	$1\frac{3}{4}$	Do.
235	12	Male......	4	4	5	14	12+13	$1\frac{2}{3}$	Do.
236	$11\frac{3}{4}$	Male......	$3\frac{4}{5}$	$3\frac{4}{5}$	5	14	14+14	2	Do.
237	$11\frac{1}{2}$	Male......	$3\frac{5}{6}$	$3\frac{5}{6}$	5	15	13+13	$1\frac{5}{6}$	Do.
238	12	Male......	$3\frac{2}{3}$	$3\frac{2}{3}$	$5\frac{1}{3}$	14	14+14	2	Perfect.
239	$11\frac{1}{2}$	Male......	$3\frac{3}{5}$	$3\frac{3}{5}$	$5\frac{1}{3}$	15	13+14	2	Do.
240	$11\frac{1}{2}$	Female ...	$4\frac{1}{5}$	$4\frac{3}{5}$	$4\frac{2}{3}$	14	14+13	$1\frac{2}{3}$	Do.
241	11	Female ...	$4\frac{1}{3}$	$4\frac{1}{3}$	$4\frac{2}{3}$	14	12+12	$1\frac{3}{4}$	Perfect, ripe.
242	$11\frac{1}{2}$	Female ...	4	4	$4\frac{4}{5}$	14	14+13	$1\frac{3}{4}$	Do.
243	$11\frac{1}{2}$	Male......	4	4	$4\frac{3}{4}$	14	13+14	$1\frac{3}{4}$	Do.
244	11	Male......	4	4	$4\frac{1}{2}$	14	13+14	$1\frac{3}{4}$	Do.
245	$11\frac{1}{2}$	Male......	4	$4\frac{1}{5}$	5	14	13+13	$1\frac{5}{6}$	Perfect.
246	$11\frac{1}{2}$	Female ...	4	4	$4\frac{2}{3}$	14	13+13	$1\frac{3}{5}$	Do.

In the following table are shown the average comparative measurements of the 125 specimens of redfish, the individual measurements of which are given in the two preceding tables.

	Small form, 117 specimens (69 males, 48 females.)	Large form, 8 specimens (6 males, 2 females).
Length	11.46	22.81
Head	3.991	3.80
Depth	4.13	4.52
Eye	4.97	6.994
Anal rays	14.13	14.12
Branchiostegals:		
Right	13.26	13.44
Left	13.61	13.55
Height of dorsal in head	1.85	2.16

7. *The young redfish.*

Not until this year have the young redfish ever been seen in the Columbia River basin by any naturalist. On July 20 Messrs. Meek and Scofield did some seining in the outlet close to Alturas Lake in shallow water and found young redfish in considerable numbers. The collections made that day contain 124 young redfish, varying in length from $1\frac{1}{16}$ to $2\frac{3}{8}$ inches and averaging $1\frac{17}{19}$ inches.

The total length of each of these 124 is given in the following table. The last seven were taken at the head of the lake, near the inlet.

Table giving lengths, in inches, of 124 young redfish taken at Alturas Lake July 20, 1894.

Length.	Length.	Length.	Length.	Length.	Length.	Length.	Length.	Length.	Length	Length.	Length.
$2\frac{3}{8}$	2	2	$1\frac{7}{8}$	$2\frac{3}{16}$	$1\frac{3}{4}$	$2\frac{3}{16}$	$1\frac{3}{4}$	2	2	$2\frac{1}{4}$	$2\frac{1}{4}$
$1\frac{13}{16}$	$1\frac{3}{8}$	$2\frac{1}{2}$	2	$1\frac{5}{6}$	$1\frac{3}{8}$	$1\frac{1}{2}$	2	$1\frac{3}{4}$	$2\frac{1}{8}$	$1\frac{1}{4}$	$2\frac{3}{8}$
$2\frac{1}{8}$	$1\frac{1}{8}$	2	$2\frac{3}{8}$	2	$1\frac{1}{2}$	$2\frac{1}{4}$	2	$1\frac{1}{2}$	$1\frac{7}{8}$	$1\frac{7}{8}$	$1\frac{7}{8}$
2	2	$2\frac{5}{16}$	2	$1\frac{7}{8}$	$1\frac{3}{8}$	$1\frac{3}{4}$	$2\frac{3}{8}$	2	$1\frac{7}{8}$	$1\frac{7}{8}$	
$1\frac{7}{16}$	$1\frac{7}{8}$	2	$1\frac{3}{4}$	$1\frac{5}{8}$	$1\frac{9}{16}$	$2\frac{1}{4}$	$2\frac{1}{8}$	$2\frac{5}{16}$	$2\frac{1}{8}$	$1\frac{3}{4}$	
$2\frac{3}{16}$	$1\frac{1}{8}$	2	$2\frac{1}{8}$	$1\frac{3}{4}$	$1\frac{5}{8}$	$2\frac{1}{8}$	2	$2\frac{1}{4}$	2	$1\frac{7}{8}$	
$2\frac{1}{4}$	$2\frac{1}{8}$	$2\frac{1}{4}$	$1\frac{1}{2}$	2	$1\frac{1}{8}$	$2\frac{3}{8}$	$1\frac{3}{4}$	2	2	2	
$2\frac{3}{8}$	$1\frac{7}{8}$	2	$2\frac{3}{16}$	$1\frac{1}{2}$	$1\frac{1}{8}$	$2\frac{1}{4}$	2	2	2	$1\frac{3}{4}$	
$2\frac{3}{8}$	2	$1\frac{7}{8}$	$1\frac{3}{4}$	$1\frac{1}{2}$	2	$1\frac{7}{8}$	2	$1\frac{3}{4}$	2	$1\frac{7}{8}$	
$1\frac{9}{16}$	2	$2\frac{1}{4}$	$2\frac{1}{8}$	$1\frac{3}{4}$	$2\frac{1}{8}$	$2\frac{3}{8}$	$2\frac{1}{8}$	2	2	$1\frac{1}{16}$	
$1\frac{13}{16}$	$2\frac{1}{16}$	$1\frac{3}{4}$	$2\frac{1}{16}$	$1\frac{3}{4}$	$1\frac{15}{16}$	2	$1\frac{13}{16}$	$1\frac{1}{2}$	$1\frac{3}{8}$	$2\frac{1}{2}$	

On September 9 we made two hauls with a large seine in Alturas Lake near the inlet. The seine was weighted so that it would sink to the bottom and it was then hauled in water 15 to 60 feet deep, where the bottom was of fine white sand covered in most places with a heavy growth of *Myriophyllum*, *Chara*, etc. Young fish were found to be very abundant among the vegetation, the species taken being, in order of abundance, *Leuciscus balteatus*, *Catostomus macrocheilus*, *Coregonus williamsoni*, *Ptychocheilus oregonensis*, *Oncorhynchus nerka*, *O. tschawytscha*, *Salmo mykiss*, and *Cottus bairdi punctulatus*.

The total number of young redfish taken was 45, the total lengths and comparative measurements of which are given in the appended table. The smallest of these 45 fish measure $2\frac{5}{8}$ inches long, the largest $4\frac{3}{4}$ inches, and the average was $3\frac{53}{180}$ inches.

Total lengths in inches and comparative measurements of 45 young redfish taken in Alturas Lake September 9, 1895.

Length.	Head.	Depth.	Snout.	Eye.	Length.	Head.	Depth.	Snout.	Eye.
$2\frac{3}{8}$	$4\frac{2}{5}$	$4\frac{3}{5}$	$4\frac{1}{2}$	$3\frac{2}{3}$	$2\frac{7}{8}$	$4\frac{1}{4}$	$4\frac{1}{2}$	[1] 6	$3\frac{1}{2}$
4	$4\frac{1}{4}$	$4\frac{3}{4}$	$4\frac{3}{4}$	4	$3\frac{1}{8}$	$4\frac{1}{4}$	$4\frac{2}{3}$	$4\frac{1}{2}$	$3\frac{2}{3}$
$3\frac{7}{8}$	$4\frac{1}{3}$	$4\frac{1}{2}$	$4\frac{1}{4}$	$3\frac{1}{2}$	$3\frac{1}{4}$	$4\frac{1}{5}$	$4\frac{1}{2}$	5	$3\frac{1}{5}$
$4\frac{3}{4}$	$4\frac{1}{3}$	$4\frac{1}{2}$	$4\frac{2}{5}$	$3\frac{1}{2}$	$3\frac{1}{8}$	4	$4\frac{1}{2}$	$4\frac{1}{2}$	$3\frac{1}{5}$
3	$4\frac{1}{3}$	$4\frac{1}{3}$	$4\frac{1}{2}$	3	3	$4\frac{1}{2}$	$4\frac{1}{2}$	5	3+
$3\frac{5}{8}$	$4\frac{1}{2}$	$4\frac{4}{5}$	$4\frac{1}{4}$	$3\frac{1}{2}$	$3\frac{3}{8}$	$4\frac{1}{5}$	$4\frac{1}{2}$	5	$3\frac{1}{2}$
$3\frac{1}{2}$	$4\frac{2}{5}$	$4\frac{2}{5}$	$4\frac{2}{3}$	$3\frac{1}{2}$	$3\frac{3}{8}$	$4\frac{1}{4}$	$4\frac{1}{2}$	$4\frac{1}{4}$	$3\frac{1}{4}$
$4\frac{1}{4}$	$4\frac{1}{3}$	$5\frac{1}{3}$	4	$3\frac{3}{4}$	$3\frac{1}{8}$	$4\frac{1}{2}$	$4\frac{1}{2}$	$4\frac{1}{2}$	$3\frac{1}{2}$
$3\frac{7}{8}$	$4\frac{1}{4}$	$5\frac{1}{6}$	$4\frac{1}{4}$	$3\frac{4}{5}$	$3\frac{1}{8}$	$4\frac{1}{6}$	$4\frac{1}{3}$	$4\frac{1}{2}$	$3\frac{1}{3}$
3	4	$4\frac{1}{2}$	4	$3\frac{1}{4}$	$2\frac{5}{8}$	$4\frac{1}{5}$	$4\frac{1}{3}$	$4\frac{1}{3}$	3
$3\frac{1}{4}$	$4\frac{1}{2}$	5	5	$3\frac{1}{3}$	$3\frac{1}{4}$	4	$4\frac{1}{2}$	$4\frac{1}{4}$	$3\frac{1}{4}$
$3\frac{7}{8}$	$4\frac{1}{5}$	$4\frac{3}{4}$	$4\frac{1}{4}$	$3\frac{1}{4}$	$3\frac{3}{8}$	$4\frac{1}{4}$	$4\frac{1}{2}$	$4\frac{1}{3}$	$3\frac{1}{2}$
$3\frac{1}{2}$	4	$4\frac{1}{5}$	$4\frac{1}{3}$	$3\frac{1}{2}$	$3\frac{1}{4}$	$4\frac{1}{5}$	$4\frac{1}{2}$	$4\frac{1}{5}$	$3\frac{1}{4}$
$3\frac{1}{2}$	$4\frac{1}{5}$	$4\frac{1}{2}$	$4\frac{1}{4}$	$3\frac{1}{2}$	$3\frac{3}{8}$	$4\frac{1}{5}$	$4\frac{1}{5}$	4+	3+
$3\frac{3}{8}$	$4\frac{1}{4}$	$4\frac{2}{5}$	$4\frac{1}{4}$	$3\frac{1}{4}$	3	$4\frac{1}{4}$	5	4	$3\frac{1}{2}$
3	4+	$4\frac{3}{5}$	5	3	3	4+	$4\frac{2}{3}$	4	$3\frac{1}{4}$
$3\frac{1}{4}$	$4\frac{1}{4}$	$4\frac{1}{2}$	$4\frac{1}{2}$	$3\frac{1}{3}$	3	4	5	$4\frac{1}{2}$	3
$3\frac{3}{8}$	4	$4\frac{1}{2}$	$4\frac{1}{2}$	$3\frac{1}{2}$	$3\frac{3}{8}$	$4\frac{1}{5}$	$4\frac{1}{2}$	$4\frac{1}{4}$	$3\frac{1}{2}$
3	4	$4\frac{2}{3}$	$4\frac{1}{5}$	3	3	$4\frac{1}{4}$	5	$4\frac{3}{4}$	3
$3\frac{1}{8}$	$4\frac{1}{4}$	$4\frac{1}{2}$	$4\frac{3}{4}$	$3\frac{1}{5}$	$3\frac{1}{4}$	$4\frac{1}{4}$	$4\frac{3}{4}$	$4\frac{1}{4}$	$3\frac{1}{4}$
$3\frac{1}{4}$	$4\frac{1}{4}$	$4\frac{1}{2}$	$4\frac{1}{5}$	$3\frac{1}{4}$	$3\frac{1}{4}$	$4\frac{1}{4}$	$4\frac{1}{2}$	4	$3\frac{1}{4}$
$3\frac{3}{8}$	$4\frac{1}{4}$	$4\frac{2}{3}$	4	$3\frac{1}{4}$	$2\frac{5}{8}$	4	$4\frac{2}{3}$	$4\frac{1}{3}$	3
$2\frac{7}{8}$	4	5	$4\frac{1}{4}$	3					

[1] Deformed.

On September 12 the seine was again hauled in the same place and 4 young redfish were caught. They measured $3\frac{5}{16}$, $3\frac{1}{4}$, $2\frac{7}{8}$, and $2\frac{7}{8}$ inches, respectively. The difference in size between those taken July 20 and September 9 and 12 is very noticeable, and throws light upon their rate of growth.

These young redfish at first sight might easily be mistaken for young trout or young chinook salmon. They can best be distinguished from young trout by the larger number of anal rays (13 to 16 in the redfish, 9 to 12 in the trout), the more slender body, and the paler coloration. From young chinook salmon they may be known by the more slender body, paler coloration, shape of the anal fin (which is not falcate, as it is in the young chinook salmon), and by the increased number and greater length of the gillrakers (about 37 gillrakers in the redfish and only about 23 in the chinook salmon).

The young redfish $1\frac{1}{2}$ inches long has the following coloration: Back pale, with bluish tinge and 25 to 30 rather large bluish-black spots, some of which are oblong and reach to or even cross the lateral line; median dorsal line dark; head dusted with dark points; lower half of side and belly plain silvery white; fins nearly plain yellowish white, unspotted. A specimen 3 inches long, taken September 12, has the same general coloration, but the back is bluer and the spots have become large, oblong, vertical bluish bars, about 12 or 15 in number, 9 or 10 extending across the lateral line; the lower sides and belly yellowish silvery.

8. *Periodicity in the run of the blueback salmon.*

The statistics of the fisheries of the lower Columbia, as well as other observations, show that the run of this species is large in the even years and small in the odd ones. The origin or meaning of this periodicity has never received an explanation. Indeed, I do not know that the phenomenon has ever received the attention of any naturalist further than merely to note the fact. The fact is one of great interest, changing as it does the character of the fishery every two years, and the search for its explanation opens up a most attractive and promising field for investigation. We know too little about the migrations of this fish, particularly of its movements up and down the coast, to warrant us in holding any decided views as to the origin of this interesting habit, if habit it may be called. An examination of the fisheries in other streams in which this species spawns may throw some light upon

the question. The statistics of the catch of blueback salmon in the Fraser River, as furnished by the Canadian Department of Marine and Fisheries, show a periodicity in the run in that river. Whether there is any connection between the runs in these two rivers, whether a large run in the one is at the expense of that in the other, is improbable, but well worth investigation.

Another explanation suggests itself: It is possible that at some time, years ago, a catastrophe of some kind or other may have occurred in the headwaters of the Columbia which resulted in the destruction of practically all the fish and spawn in the river at that time. Then, upon the supposition that this species reaches maturity in two years (which is wholly improbable), and that it spawns only once (which our observations proved), there would be few if any fish to come to the spawning-grounds the second year after the catastrophe; and this break would be self-perpetuating, and thus would the light run on alternate years be accounted for.

The principal, and I think fatal, weakness in the hypothesis is the supposition that this salmon spawns at 2 years of age. Our observations at Alturas Lake indicate that the young remain near where they were hatched for about one year, and that at 1 year old they are only about 6 inches long. To go down to the sea, grow to a length of 2 feet or more and a weight of 5 to 7 pounds, and then return to the spawning-beds, would at the lowest possible calculation require at least two years more.

Each of these hypotheses appears very improbable and unsatisfactory. The solution must wait for additional knowledge concerning the life-history of the species.

16. Salmo mykiss Walbaum. *Columbia River Trout; Cut-throat Trout; Black-spotted Trout.*

Black-spotted trout are abundant in all suitable waters in Idaho. Our collections of 1894 and 1895 contain numerous specimens, representing the following localities: Snake River at Upper Salmon Falls; Mann Creek 10 miles from Weiser; Little Weiser River at Indian Valley; Payette River and Big Payette Lake; Big Wood River near Galena; Beaver Creek, Alturas Lake, Alturas Creek, Meadow Creek, Warm Springs Creek, and Salmon River near Sawtooth, and Fish Lake near Redfish Lake. A study of these specimens has not led to any satisfactory conclusion as to what varieties, if any, should be admitted.

The specimens from Upper Salmon Falls and Mann Creek have the small scales and the red throat of subspecies *clarkii*, as defined by Jordan & Evermann. The numerous examples from Payette River and Big Payette Lake are less spotted, and have little, if any, red upon the throat. Two specimens caught in Big Payette Lake September 27, 1894, had the following colors: A male, 15 inches long—spots small, half circles, few below middle of side; rosy wash on side and opercles; scarcely any red on throat; belly silvery, back dark-greenish; scales about 145, gillrakers 10 + 10, branchiostegals 11, anal 12; stomach empty, except three pine seeds. A female, 14¾ inches long, had the spots the same as in the male, the sides less rosy, and scarcely any red on throat; scales about 140, gillrakers 7 + 12, branchiostegals 11, anal 11; stomach filled with small crustaceans.

Two other examples taken in the same lake September 27 possessed essentially the same color markings, as do also the specimens sent in by Mr. Williams. These are certainly the variety *gibbsii*, and are locally known as the silver trout. They are abundant in Big Payette Lake. On the morning of September 27, while sailing from the foot to the head of this lake, trout could be seen jumping in various places; one or more could be seen at any time, while usually 5 to 15 or 20 could be seen jumping out of the water and glittering in the morning sun. They are said to spawn at this lake in June, running up the smaller streams for that purpose.

Trout are very abundant in the upper part of Big Wood River, and the collections contain several specimens from the vicinity of Galena. A fine specimen, a female 14 inches long, taken with the fly by Mr. Barnum in this stream September 24, had the following life colors: Back, dark steel color, thickly covered with small round black spots; middle of side and cheek with a broad wash of rosy red; lower parts silvery; black spots very numerous on back and on dorsal and anal fins, less thick below lateral line; no red on throat. Other examples from the same stream were examined and found to agree with the one just described in the abundance of spots, the rosy sides, and the almost entire absence of red on the throat.

These Wood River trout seem, therefore, closest to variety *gibbsii*.

Young trout were found to be abundant in the Redfish Lakes, while in the streams of the Upper Salmon Valley trout ranging from one-fourth of a pound up to 2 or 3 pounds were very plentiful. Among the streams that afforded particularly good trout fishing were Beaver, Smiley, Pole, and Alturas creeks and Salmon River. During our stay the best fishing was in July, but in the smaller streams

and certain small lakes it continued good throughout the season. Very large catches were made in the small creeks in July, August, and October, but in Alturas Creek and Salmon River July seemed the best time.

Near Redfish Lake is a small lake known as Fish Lake. Its area is perhaps not greater than 25 acres. It is nearly circular in form and is at an elevation of about 9,000 feet. It appears to be quite shallow and is bordered on three sides by marshy or boggy ground. In this little lake trout were exceedingly abundant. On August 22, 100 were caught by Mr. Comstock, of Hailey, and the next day I caught 45 trout from the same lake in less than an hour's time; used Royal Coachman for nearly all, though a few were taken with grasshopper. They bit vigorously and were very gamy.

These trout were remarkably uniform in size, the total length varying only from 8 to 9½ inches, the majority being 9 to 9¼ inches. The weight varied but little from one-fourth of a pound each. In life they presented the following colors: Throat rich rosy red in every case; opercles light rosy; lower part of sides and belly, except median line, rich wine color or dark rosy; middle of side with about 6 to 8 large dark rosy blotches forming an irregular band along the side; whole posterior part of body, dorsal and caudal fins thickly covered with large, more or less stellate, black spots; spots on anterior part of body and on head less numerous. Some examples with a yellowish shade on side; others were very dark, the spots on the posterior half of the body being very close-set.

The trout caught in Salmon River and Alturas Creek agree with those from Fish Lake in the red throat and rosy sides, but are larger, deeper fish, and not so profusely spotted. Those caught in Beaver and Smiley creeks were all small, averaging only 4½ to 5 inches in length. They were usually pretty well spotted, but showed no red on the throat and but little on side. These appear to be mature fish and are said to spawn in July—Mr. Parks thinks between July 15 and August 15, and that they will not bite well after September 1.

In Meadow Creek and the sloughs along Salmon River young trout 1½ to 2¼ inches long were very abundant. In Meadow Creek they were associated with young chinook salmon and young whitefish, but along Salmon River they were about the only fish found. In Alturas Lake a few were found with the young redfish, whitefish, and chinooks, but we are not sure that we ever saw any trout, young or adult, in the inlets to any of these lakes. From young salmon or redfish the young trout may most easily be known by its smaller anal fin, which has only 9 to 12 rays, while in the other species there are 13 to 16.

17. Salmo gairdneri Richardson. *Salmon Trout; Steelhead Trout.*

As shown in the former report, the salmon trout is an important fish in Idaho. The investigations of 1895 added nothing to the information obtained in 1894 and given in that report. In order to study the spawning habits of this fish in the headwaters of Salmon River it will be necessary to be on the ground by the last of April and remain until some time in June. It is not improbable that some of the very small trout which we obtained were really the young of this species. I know of no certain way by which to distinguish the young of the steelhead from young *Salmo mykiss.*

18. Salvelinus malma (Walbaum). *Bull Trout; Dolly Varden Trout.*

The bull trout was seen by us in Salmon River and Alturas and Pettit lakes, inlets and outlets. It was not seen in Yellowbelly, Redfish, or Big Payette Lake, but it is said to occur in all those waters. Not until these investigations was the Dolly Varden or bull trout known to occur in the Snake River basin, and it is not yet known from any point above the Great Shoshone Falls. In Salmon River and Alturas Creek it seemed to be quite common during July and August, and could be readily taken on the hook with almost any kind of bait. Salmon spawn tied up in pink mosquito bar, grasshoppers, and fish liver were excellent bait. It would sometimes take the fly and always proved a vigorous fighter. In these waters this species attains a weight of 3 or 4 pounds. Its spawning season is in August and September.

This is the only fish, excepting young salmon, which we saw in Alturas Inlet with the spawning redfish. On September 8 a large male bull trout, 22 inches long and weighing 3 pounds, was found in Alturas Inlet near the mouth. This was a spent fish and seemed in good condition except that the upper caudal lobe was gone, apparently bitten off by some animal. The spots on sides were very bright red, and the belly as high up as the pectorals was a beautiful rosy red; the anal, ventrals, and pectorals margined with white, that on the pectoral inclining to yellowish.

19. Uranidea bendirei (Bean).

The only place where this species was found was in Goose Creek, near Meadows, Idaho. Goose Creek is a small tributary of Little Salmon River, which flows into Salmon River about 35 miles north of Meadows. The specimens are 6 in number, and were obtained by Mr. Williams July 18. The largest are about 3 inches long. They differ from *C. rhotheus* in having the ventrals I, 3 (I, 4 in *rhotheus*), in the absence of prickles, as well as in other respects. Our specimens agree well with the type which was obtained by Major (then Captain) Bendire in Rattlesnake Creek, near Camp Harney, Oreg., May 2, 1878. This is the second locality from which this species has been recorded.

20. Cottus rhotheus (Rosa Smith).

This species of blob was obtained at the following places: Small creek at Snow's in Indian Valley, September 24, 1894, 4 specimens; Meadow Creek near Sawtooth, July 28 and 30, 23 specimens; Alturas Lake, July 20, 2 specimens; August 9, 2 specimens, and September 10 and 12, 4 specimens; Pettit Lake Outlet, July 22 and August 14, 3 specimens; Payette River near Payette Lake, August 18, 3 specimens; Redfish Lake, August 22, 1 specimen. This seems to be the only blob in the Sawtooth region, and is not very common, the specimens mentioned above, 35 in number, being all we were able to obtain without special effort during the season's work.

They appear to be about equally common in the lakes and the streams. The largest examples obtained are 3 inches in length. As among the other species of this genus, there is much variation in color among these specimens, but the general pattern agrees fairly well with that assigned the original types. The prickles on the anterior part of the body are well developed, and in most cases they extend well onto the caudal peduncle. The dorsal fins are connected in some specimens, while in others they are separate.

This species was obtained by Dr. Eigenmann in 1892 in Snake River at Idaho Falls, and by Gilbert & Evermann in 1893 in Cœur d'Alene Lake near Cœur d'Alene, Idaho, and in Clearwater River near Lewiston, Idaho.

The following table exhibits the variation in fin rays as shown by 28 specimens:

Locality.	Dorsal spines.		Dorsal rays.		Anal rays.				Number of specimens examined.
	VII.	VIII.	16.	17.	11.	12.	13.	14.	
Pettit Lake, outlet	1	2	3			3			3
Meadow Creek, near mouth, Sawtooth, Idaho	1	9	4	6		5	4	1	10
Alturas Lake, Sawtooth, Idaho	2	6	6	2	2	4	2		8
Indian Valley, Idaho	1	3	4			2	2		4
Payette River, Lardo, Idaho	3		2	1		3			3

21. Cottus leiopomus Gilbert & Evermann.

This species of blob was described in 1894 (Bull. U. S. Fish Commission for 1894, 203, pl. 20, fig. 2) from 2 specimens obtained by Mr. H. H. Kinsey from Upper Little Wood River near Shoshone. No additional specimens have been collected.

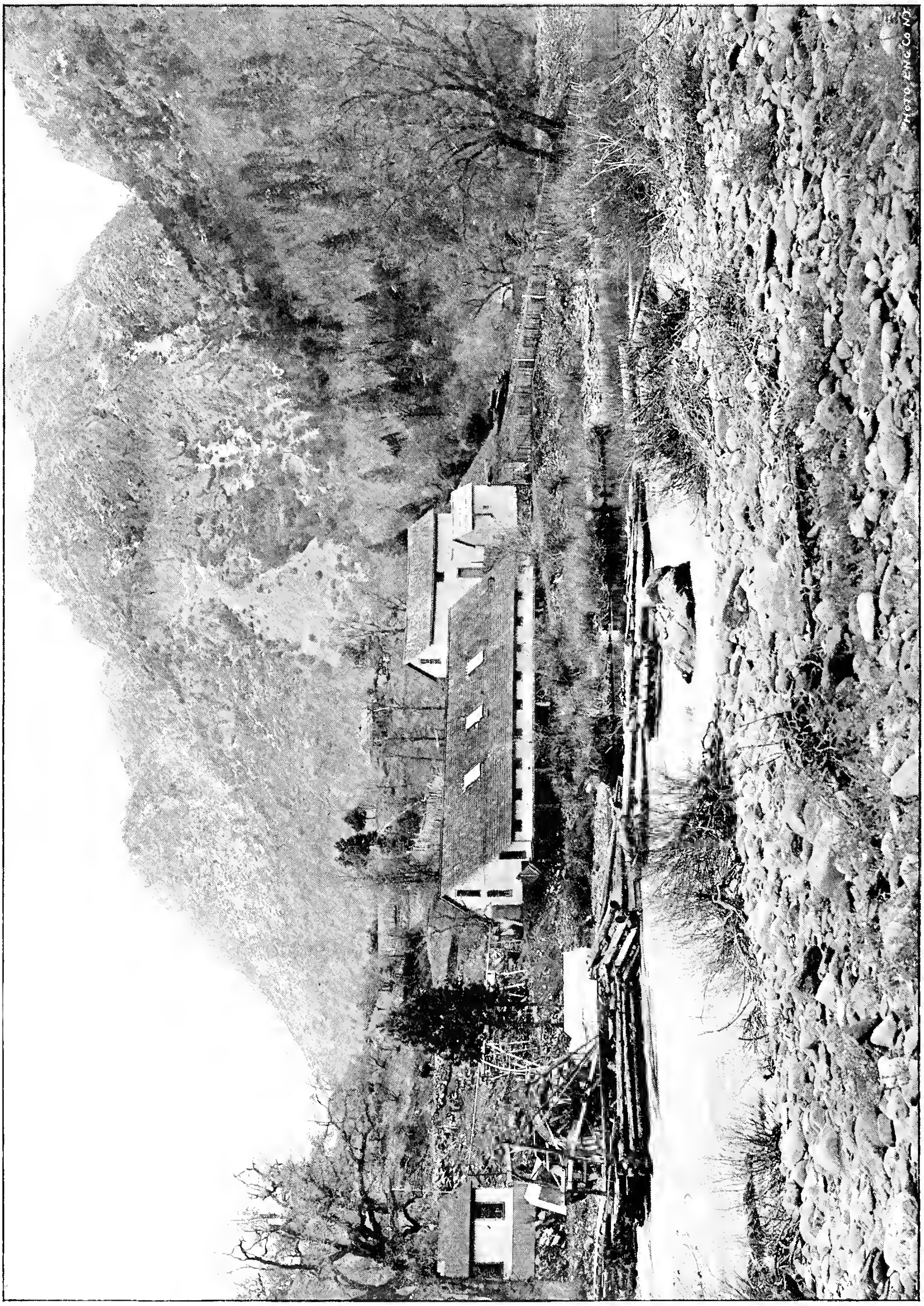
INDEX TO REPORT ON EXPLORATIONS IN IDAHO.

THE ARTIFICIAL PROPAGATION OF SALMON ON THE PACIFIC COAST OF THE UNITED STATES,

WITH

NOTES ON THE NATURAL HISTORY OF THE QUINNAT SALMON.

By LIVINGSTON STONE, A. M.



BAIRD STATION. THE McCLOUD RIVER IN THE FOREGROUND; IN THE BACKGROUND THE LIMESTONE ROCKS OF MOUNT PERSEPHONE. ENGINE HOUSE AND CURRENT WHEEL. HATCHING HOUSE. STABLE AND STOREHOUSE.

3.—THE ARTIFICIAL PROPAGATION OF SALMON ON THE PACIFIC COAST OF THE UNITED STATES, WITH NOTES ON THE NATURAL HISTORY OF THE QUINNAT SALMON.

By LIVINGSTON STONE, A. M.

A BRIEF HISTORY OF THE SALMON-BREEDING WORK OF THE UNITED STATES FISH COMMISSION ON THE PACIFIC COAST, WITH ESPECIAL REFERENCE TO OPERATIONS AT BAIRD STATION, CALIFORNIA.

In 1864 the New Hampshire legislature had the intelligence and foresight to appoint a fish commission—the pioneer fish commission of the United States—at the suggestion of Hon. Henry A. Bellows, of Concord. Two years after, in 1866, the commission sent Dr. W. W. Fletcher to New Brunswick to procure salmon eggs for Merrimac River. This was the first effort ever made in America in the direction of salmon breeding. Only two or three hundred fry were actually known to have resulted from this expedition, but it was a beginning—a small beginning, it is true, but one which opened up a field of operations that has since been enlarged beyond the most sanguine expectations.

In 1867 Dr. Fletcher went again to New Brunswick, under the auspices of the New Hampshire Commission, and brought back 70,000 salmon eggs, of which about 10,000 were successfully hatched.

The next year, 1868, the writer, in connection with Mr. Joseph Goodfellow, of New Brunswick, put up a large salmon-hatching plant on Mirimichi River, and began the first systematic operations on this side of the Atlantic for taking and hatching salmon eggs. The neighboring residents,[1] however, very naturally jealous of the attempts of a foreigner to carry off their "salmon seed," as they expressed it (although by explicit stipulations half of the eggs were to remain in New Brunswick), threw so many obstacles in the way that it was only by persistent effort, in the face of most discouraging opposition, that any salmon eggs at all were secured, the whole output of the season amounting to only 443,900 eggs, and the next year the local public sentiment was so hostile that this hatchery, constructed on a large scale and almost ideal in its natural adaptability to its purpose, had to be abandoned altogether.

Very little was done in 1869 and 1870 in getting salmon eggs for the United States, except by purchase from the Canadian government, the price paid at that time being the preposterous sum of \$40 in gold per 1,000, or nearly \$45 in the then depreciated currency of the United States.

In 1871[2] Mr. Charles G. Atkins, of Maine, began operations in salmon breeding on the Penobscot, and obtained 72,300 eggs, at a cost of \$18.09 per 1,000.

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[1] See *Domesticated Trout*, page 315.

[2] Mr. Atkins has continued successfully to take salmon (*Salmo salar*) eggs on the Penobscot up to the present time (1896).

In the summer of 1872, at a meeting of members of the Fish-Culturists' Association and State fish commissioners, called, I think, by Prof. Spencer F. Baird, the United States Fish Commissioner, the subject of obtaining salmon eggs on a large scale was discussed, the writer advocating the plan of operating on the Pacific Coast,[1] where millions of eggs could be taken at the cost of a few hundred thousand obtained on the Atlantic Coast. One of the results of this meeting was that the writer was commissioned by Professor Baird to go to the Pacific Coast in search of salmon eggs. Professor Baird's instructions were contained in the following letter:

UNITED STATES COMMISSION OF FISH AND FISHERIES,
Eastport, Maine, July 6, 1872.

DEAR SIR: An appropriation of $15,000 was made by Congress, at its last session, to be expended under the direction of the United States Commissioner of Fish and Fisheries, for introducing salmon, shad, and other useful food-fishes into new and suitable waters of the United States. At the recommendation of members of the Fish-Culturists' Association and certain State fish commissioners, I hereby appoint you a deputy commissioner, to proceed without delay to the Pacific Coast, in connection with this object. Your compensation in full for your services will be $250 a month, your pay commencing when you start for the West.

The sum of $750 will be allowed you for expenses of traveling and of investigation for the fiscal year, and a further allowance of $1,250 for the same period will be made for the cost of erecting and maintaining a hatching establishment, and for other necessary expenses connected with the packing and transportation of the eggs, etc.—$5,000 in all.

You will proceed to California at the earliest possible moment, and on arriving there put yourself in communication with the commissioners of the State of California and endeavor to obtain their assistance in your mission. If you can make arrangements to obtain, at reasonable cost, all the eggs that you desire in California, without proceeding farther north, you are hereby authorized to do so, but otherwise you will extend your journey to the Columbia River and adjacent waters, and if the season is not too far advanced you will proceed at once to make arrangements for obtaining a supply of salmon eggs; previously, however, by examination and counsel with those who are familiar with the subject, fixing upon the species best adapted for the purposes in question.

The general treatment of the whole subject must be left largely to your discretion, bearing in mind that the object is to lay the foundation of an arrangement, on a large scale, for obtaining eggs of the best varieties of *Salmonidæ* and other food-fishes of the western coast.

Very truly yours,

SPENCER F. BAIRD,
Commissioner.

LIVINGSTON STONE, Esq.,
Charlestown, New Hampshire.

Perhaps I can not better give an account of what immediately followed than by quoting from my first report to Professor Baird, dated December 9, 1872:[2]

In pursuance of your instructions, received in July last, to proceed without delay to the Pacific Coast and make arrangements for obtaining a supply of salmon eggs, I left Boston on the 1st day of August for San Francisco, with this object. As I was directed in subsequent letters to obtain, if possible, the eggs of the Sacramento River salmon, I set myself at work at once to ascertain the time and place of the spawning of these fish, but, singular as it seems, I could find no one in San Francisco who was able to say either where or when the salmon of the Sacramento spawned.

Fortunately, a short time after, I was introduced, through the kindness of Hon. B. B. Redding, a member of the board of California commissioners of fisheries, to Mr. Montague, the chief engineer

[1] It may be well to mention here that the subject of this paper, viz, the quinnat salmon, must not be confounded with the other salmon of the Pacific Coast. The Atlantic has but one kind of salmon (*Salmo salar*), but the Pacific has five species, as follows: The quinnat salmon (*Oncorhynchus tschawytscha*), the blueback salmon (*O. nerka*), the silver salmon (*O. kisutch*), the dog salmon (*O. keta*), and the humpback salmon (*O. gorbuscha*). In addition to these the steelhead (*Salmo gairdneri*) is commonly known as a salmon, though really a trout. Although these salmon in some general features resemble the quinnat, they are very different from that fish in many matters of detail.

[2] United States Fish Commissioner's Report, 1872–73, page 168.

of the Pacific Railroad, who showed me the Pacific Railroad surveys of tho upper waters of the Sacramento, and pointed out a place on the map, near tho junction of McCloud and Pitt rivers, whero he assured me ho had seon Indians spearing salmon in the fall on their spawning-beds. This point is 185 miles north of Sacramento City. Following this clue I procceded to Red Bluff, tho northernmost railway station of the California and Oregon Railroad, situated 50 miles from McCloud River. From inquirios made there I became so well convinced that tho salmon were then spawning on McCloud River, that as soon as supplies and men could be got ready I took the California and Oregon stage for Pitt River ferry, a mile from the mouth of the McCloud. We arrived hero at daylight on the 30th of August. Leaving tho stage at this point wo followed up the west bank of Pitt River on foot to the mouth of the McCloud, and continued thence up McCloud River.

At a distance of about 2 miles above the mouth of the river wo came upon soveral camps of Indians with hundreds of freshly caught salmon drying on tho bushes. Salmon could also bo seen in the river in such numbers that we counted 60 in one spot as wo stood at tho water's edge. It was evident that this was the place to get tho breeding fish, and the next thing was to find water to mature tho eggs for shipment. This was not so casy a task as finding the salmon, but we at last discovered a spring stream flowing 1,000 gallons an hour, which I decided to use, this season at least, and on the morning of September 1, 1872, the hatching works of the first salmon-breeding station of the United States were located on this stream.

The location is about 2 miles up McCloud River, on its western bank. It is 323 miles from San Francisco, via Pacific Railroad; 453 miles from Portland, Oreg., and is on tho California stage road, which, at the time of our arrival, connected with the railroad at Red Bluff. The spawn found in the salmon that the Indians were spearing on our arrival indicated that there was no time to spare in getting ready for the hatching work. We were 25 miles from the nearest town or village, 50 miles from a railway station, over 50 miles from an available sawmill, and in the Sierra Nevada Mountains, where the mule teams barely made 20 miles a day with supplies; but we went to work, and in 15 days wo had a house built, filtering-tanks, hatching-apparatus, and flume in perfect running order, and on tho 16th of September we were catching and corralling salmon. There were but three of us, and every day for a week the mercury ran from 105° to 112° F. in the shade. But although we worked so expeditiously through the broiling sun of those days, we were too late. The first few hauls of the net showed that the salmon had spawned. In fact, tho salmon begin to spawn in McCloud River some time in August and are through spawning, or nearly through, by the 20th of September.

We caught plenty of salmon in the seine, but only rarely a female with ova. By hard fishing and hauling the seine every night, and sometimes all night, we succeeded in catching 26 salmon, including both sexes, in spawning condition, by the 28th of September. On the night of the 28th, at midnight, as the returns did not seem to warrant the expense of handling the seine, I stopped fishing. Of the 26 breeding salmon caught, 12 were females, and yielded 50,000 eggs. Of this number, 20,000 wero destroyed by the terrible heat of the last of September, the mercury on some days reaching as high as 112° in the shade. The remaining 30,000 did well in spite of many dangers from sediment and from a fungoid growth which seemed to penetrate the brook water on hot days, and which rendered constant vigilance necessary; and on the 12th day of October the most advanced eggs showed eye-spots. By Friday, October 18, all the eggs were ready to pack for shipment, but, owing to miscarriage of a letter, the moss, which was to be delivered on the previous Tuesday, did not arrive until the evening of the following Tuesday. On the next day, October 23, the eggs were packed and shipped to Sacramento, where I placed them in charge of Wells, Fargo & Co., by whom they were forwarded east on the 25th of October, 1872.

These were the first live salmon eggs that crossed the continent from the Pacific to the Atlantic.

Here let me quote again from the same report:[1]

The conditions of hatching salmon eggs in California are wholly different from those which present themselves in similar work in the East.

At the East you have to guard against cold, in California you havo to guard against heat; at the East you can usually find a good spring in a favorable locality; here it is out of the question; at the East a brook will usually answer tho purposes of hatching water in the absence of a spring; in California the brooks as a rule are wholly unsuitable for hatching; at the East the eggs are hatching

[1] United States Fish Commissioner's Report, 1872–73, pages 171–173.

in the winter; in California the salmon spawn in the summer; and finally, most of the hatching work is done in California before the Atlantic fish begin to spawn.

I tried three ways of capturing the parent salmon; first, by the Indian trap; second, by a stake net and pound; third, by a sweep seine. The Indian trap consists of a fence of stakes or bushes built out into the river at a fall or rapid in the form of a letter V, having the angle downstream, and a basket trap at the angle. This method proved perfectly worthless, as of course it must, for catching healthy fish, as this contrivance catches only the exhausted fish that are going down the river and none of the good fish that are coming up.

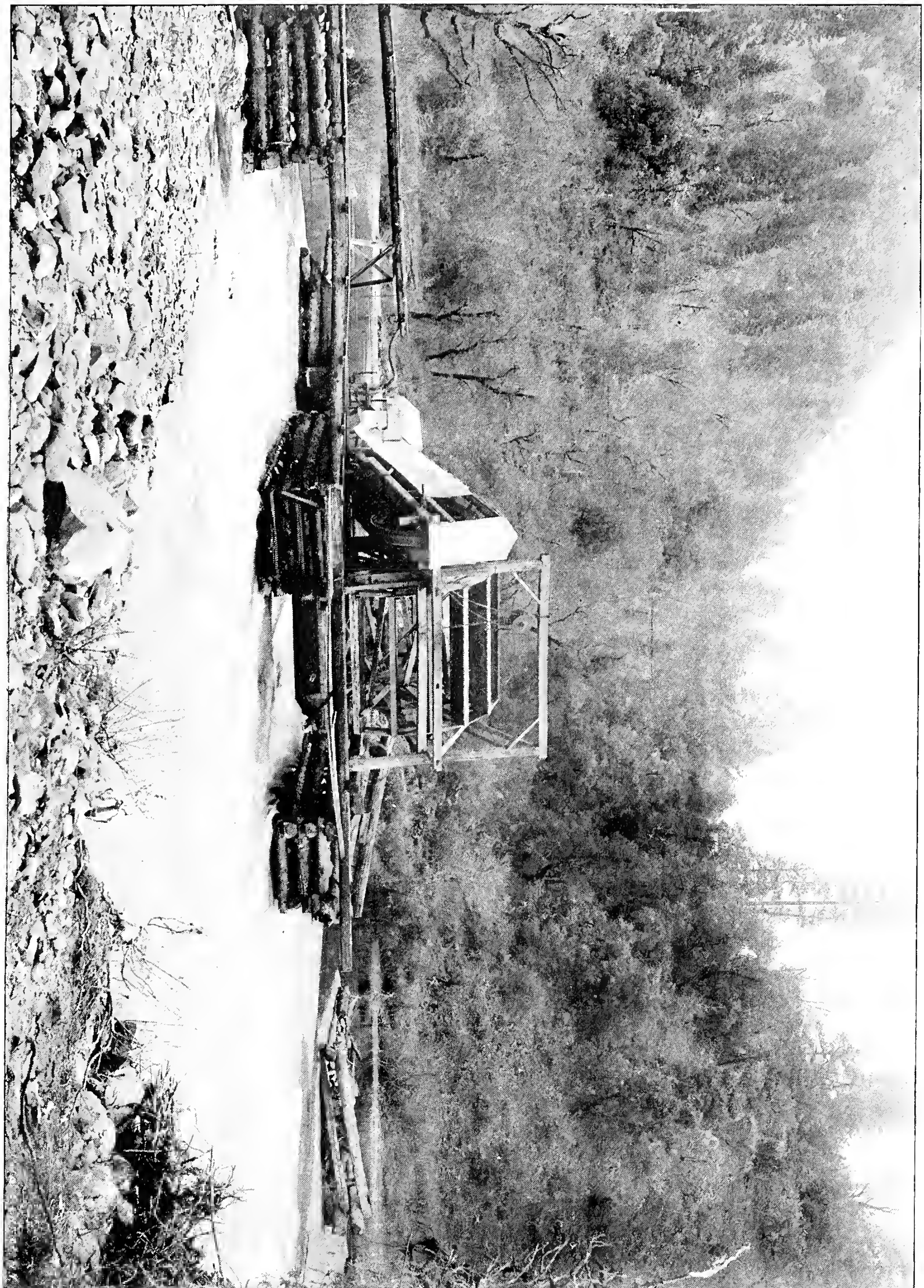
The second method of using a stake net did not work, on account of the volume and force of the river current. I set the stake net so as to just reverse the form of the Indian trap; that is, so that it formed the letter V with the angle upstream, and a trap or pound in the angle. As it happened, it was too late for such a net to be effective, because the salmon were all going down at that time, and none, or at most a very few, were coming up; but even if the salmon had been coming up, this contrivance would not have answered here as a permanency, because the velocity and volume of water in the McCloud are such as would ultimately tear any such net away in any place where it could otherwise be set to advantage.

The third method, of sweeping with a seine, worked to perfection. In some of the holes, and especially in one large hole near which it is proposed to place the hatching works next year, any number of parent salmon can be caught in the proper season. The only objection to hauling a seine in these places is that as the boat taking out the seine turns to come ashore again it is drawn near the brink of the rapids, over which it would be dangerous to go in the night. This is an objection, however, which skill and nerve can always overcome.

On the darkest nights the scene on the river bank was exceedingly wild and picturesque. Behind us was the tall, dark shadow of Persephone Mountain, and before us at our feet ran the gleaming rapid current of the McCloud, while the camp fire threw an unsteady light upon the forest, mountain, and river, suddenly cut off by the dense darkness beyond. The flaming pitch-pine torches stuck into the sandy beach at intervals of 20 feet to guide the boatmen, the dusky forms of a half-dozen Indians coiled around the fire, or stoically watching the fishing, the net, the fishing boat, and the struggling fish added to the effect, and made a picture which, especially when the woods were set on fire to attract the salmon, was one of surpassing interest. It was quite impressive, in the midst of these surroundings, to reflect that we were beyond the white man's boundary, in the home of the Indian, where the bear, the panther, the deer, and the Indian had lived for centuries undisturbed.

As will be seen by the foregoing, Baird station of the United States Fish Commission was founded in August, 1872. It was known as McCloud River station until 1878, when the writer, having succeeded in getting a post-office established on the river, named the post-office "Baird," after the distinguished first Fish Commissioner of the United States, Hon. Spencer F. Baird, since which time the station has been called Baird station.

The first plant on McCloud River was a very modest affair. It consisted of a rough-board, one-room cabin, 10 by 14 feet, and 24 hatching-troughs in the open air, each covered, of course, but with no roof over them. The results of the first year were modest enough, too. The whole net product of the season's operations was only 30,000 salmon eggs, costing over $100 per 1,000, and when these were shipped across the continent to their destination in New Jersey 24,000 were lost in transit, leaving only 6,000 good eggs to be hatched and planted in the tributaries of the Atlantic. Nevertheless, two important facts were established by the experiment, compared with the value of which the cost of the enterprise was trifling. The experiment established the fact that salmon eggs could be obtained in future from the Pacific Coast, and probably in large quantities, and also the fact, most important of all at that time, that salmon eggs could be shipped alive across the continent. The last fact was the more valuable, because up to that time salmon eggs had never been subjected to a long journey by rail, and serious doubts had been often expressed by experts as to the possibility of getting salmon eggs alive from the Pacific to the Atlantic.



CURRENT WHEEL AND CONNECTIONS WITH CENTRIFUGAL PUMP, TOGETHER WITH SOME OF THE PIERS WHICH SUPPORT THE RACK ACROSS THE McCLOUD RIVER.

Previous to this year the Pacific Coast, as a source of supply in procuring salmon eggs, was an untried field. No one knew anything definite about it. Everything was conjectural. The sending off, also, of the delicate embryos packed in wooden boxes, to run the gauntlet of the vague and innumerable dangers of a journey across the continent, seemed like sailing out into an undiscovered sea; but now that the season was over the untried field had become familiar ground, and a path over the unknown sea had been found. In the number of eggs procured the results of the first year were small, but in the practical demonstration of what it was possible to accomplish on the Pacific Coast, the results of the first year's operations on the McCloud equal or surpass those of any subsequent season.

It may also be mentioned here that a valuable mass of information concerning the natural history of the salmon of the Sacramento was obtained this year, and 270 valuable specimens of the fauna of California, chiefly fishes, of course, were collected and forwarded to the Smithsonian Institution.

The next year (1873), wishing to follow up the lead now clearly brought to view, Professor Baird dispatched the writer a second time to California, with instructions to procure as many salmon eggs as possible.

Here I will quote from my reports:

Having secured supplies and men for the season's campaign, I left this (San Francisco) city again for McCloud River on the 5th of August, arriving at camp the next morning at daylight.

The year before, the idea of using McCloud River water not having suggested itself, I had been obliged to locate the camp and hatching works at a considerable distance from the river in order to obtain brook water for maturing the eggs. The inconvenience of this arrangement, which placed the fishing-grounds and hatching-works a mile apart, is apparent. In fact, the constant necessity for crossing and carrying materials from one point to the other, frequently in a temperature of 100° F. in the shade, became so intolerable before the season was over, with its consequent labor, risk, and loss of time, that I resolved, if possible, the next season to bring the camp, hatching-works, fishing-grounds, and stage communication together at one place. This I was fortunately enabled to do by using the river water for hatching at a point where the California and Oregon stage road touches the west bank of the McCloud. The first plan for conveying the water supply from a higher part of the river to the hatching works was not successful, on account of there not being sufficient fall for a satisfactory hatching apparatus, and for other reasons. This plan was therefore abandoned and the attempt was made to raise water from the river by a wheel placed in the current. This method worked to our entire satisfaction.

Having moved the station to the bank of McCloud River, we began fishing in midsummer, thinking that the salmon could be caught and safely confined until the coming of the spawning season rendered them ready for use. In this we met with a great and complete disappointment.

The confinement of the parent salmon in suitable inclosures, though it seems so simple a matter, was a very trying and difficult problem to solve, and gave us no end of trouble. To show the character of this difficulty, I will give my experience in the order in which it came. We began building our inclosures by staking down a small circular fence of stakes in a shallow place in the river near the shore. The stakes were driven down one by one, very firmly, and then firmly bound together and held in their place by withes. The main objection at first to this was that it was on too small a scale. We then built other inclosures on the same plan, but larger and deeper. This, however, gave the fish more scope for jumping, and, although the top of the stakes was several feet above the surface of the water in the inclosure, the salmon easily jumped over them and escaped into the river. We then put a covering, or roof, over the corral on a level with the top of the fence. The salmon now, although they could not escape by jumping out, were no less persistent in their attempts to do so, and literally wore and lashed themselves to death in their frantic and ceaseless efforts to escape. I then built a large, covered, wooden box, 16 feet long and about 4 feet deep and 5 feet broad, with wide seams between the boards to let the water through, and anchored it in the current. As the box, when soaked, sank nearly its depth in the water, the salmon had no chance to jump and lash themselves as in the staked inclosure, and we flattered ourselves we had found the solution of this troublesome problem

of providing a suitable place of confinement; but what was our surprise and disappointment when, on examining the box a few days later, we found the salmon all dead. The close confinement had really prevented them from injuring themselves as before by jumping, but at the same time had acted so unfavorably in other ways as to cause their death.

The prospect now looked very discouraging. We could catch salmon enough for our purpose, but we could not keep them alive. They were, in fact, dying as fast as we caught them. It now occurred to us that an open pond, supplied by a good stream of river water, would obviate the difficulties presented, as the fish, having nothing but dry land to jump onto, would give up jumping and remain quiet. I accordingly put on a force of Indians at once, and in a few days had a pond of considerable size ready, and supplied by a stream of water taken from the flume which conveyed the river water from the wheel to the hatching-house. A large number of salmon were then put in here, and we felt decidedly encouraged. But now a new difficulty presented itself, viz, the fish would not ripen in the pond. Whether it was that the roiling of the pond by their movements when frightened prevented the eggs and milt from maturing, or whether the friction produced by their incessant jumping in the river is one of the necessary conditions of their ripening, I do not know, but it is certain that neither eggs nor milt matured in the pond, and I think we did not take a single ripe egg or any first-rate milt from one of the fish there confined. My next move was to build a close board floor over the staked inclosures in the river, almost touching the surface of the water. This prevented the fish from wearing themselves out by jumping and did not seem to interfere with their ripening, but it did not keep them wholly from dying. At last I became convinced, and am still of the opinion, that the Sacramento spawning salmon can not be kept alive in any inclosure on a small scale. There seemed now to be but one alternative left, and that was to let those die that were confined, and to keep on fishing and select such fish as we could use as we went along. This we did, and fortunately there were so many fish running in the river that we were able, even after this, to obtain enough to furnish the requisite supply of eggs.

Two million salmon eggs were taken this season on the McCloud, most of which were shipped across the continent. It was not a large number, but, as in 1872, it demonstrated two important facts: one was the certainty that large numbers of eggs could be obtained here, the other that a large percentage of the eggs could be shipped across the continent alive and in good condition. Previous to the operations of this year it was not known positively that great quantities of salmon eggs could be procured on this coast, nor was it by any means thoroughly established that most of the eggs could make the journey across the continent safely. When this season was over, however, it was known that an immense number of salmon eggs could be obtained on this coast, and also that a great majority of them could be sent alive to the Atlantic.

I will now quote from the report of the United States Fish Commissioner for 1873–74, relative to some of the difficulties encountered and the means employed:

In the season of 1872 I used water for hatching from a spring brook which emptied into the McCloud a short distance above the site of our present camp, and which had its source about a mile to the west of the river. This brook gave us no end of trouble, on account of its unsuitableness to its purpose. Its average flow in the morning was a little over 1,000 gallons an hour, but at night, after a very hot day, it would shrink to 250 gallons. It would also heat up some days to a very dangerous temperature; then, again, the hogs, which here run in the woods in a semi-wild state, would wallow in it and make it so roily that all attempts to filter it clean were fruitless; and last, but not least, there was present in the water all the time a vegetable growth, resembling our eastern *Conferva*, yet somewhat dissimilar to it, that no device of ours could cleanse the water of. It seemed to be ubiquitous, and gave a great deal of trouble.

These combined disadvantages of the water supply of 1872 decided me to abandon it this season and to look elsewhere for water. But here a new difficulty arose. There was no other spring or brook of any magnitude within several miles. To go that distance to locate would either destroy our stage communication or take us away from the river. There was but one alternative left, and that was to take the water supply from the McCloud. To accomplish this, a ditch was commenced about 50

rods above the new hatching-house site aud was continued for 200 feet, when it was abandoned, the obstacles in the way of its successful prosecution making it practically useless.

We were now left without any water supply whatever. There were salmon in abundance at onr very feet, but no water to hatch the eggs with. In this emergency the idea of raising water from the river itself by a wheel was sngested and immediately put iuto practice. From this time till it was finished, the wheel was the central object of interest at the camp. So much depended upon it and its successful working, and the project was so novel and unprecedented, that the progress of the work on it was watched with the greatest solicitude, and at last, when it was completed and actually revolved and lifted its 6,000 gallons of water an hour higher than our heads and poured it down the flnme into the hatching-troughs, our relief and enthusiasm were unbounded. I celebrated the occasion by raising at sunset a large American flag over the camp.

The next year, 1874, the problems of proeuring the salmon eggs and sending them to the Atlantic having been solved, the question on hand was how to obtain as many eggs as the conditions rendered possible. The solution of this question was very nearly reached this year, 5,000,000 eggs being secured.

The principal events of this year at the station were the introduction throughout the whole hatehing-house of the deep trays with the Williamson troughs, and the building of a salmon-proof raek entirely across MeCloud River, just opposite the station, in order to hold the breeding salmon in the vicinity of the seining-ground by preventing them from going any farther up the river, their instinct, of course, keeping them from going down the river. Both these devices worked admirably.

I will quote from the Commissioner's report for 1872–73:

The deep trays answered their pnrpose to perfection. The water, entering from the bottom and finding its exit from above the eggs, necessarily permeated all of them continually. It also kept the eggs suspended to a certain degree in the water, so that the underlying tiers were partly relieved of the weight of those above them. At first we placed the eggs in these trays 8 layers deep, but as the season progressed the deep trays worked so well that the layers were increased to 12, and, so far as could be learned, without detriment to the eggs.

I am free to say that this combiuation of deep wire-netting trays with the Williamson plan of hatching-troughs is the best apparatus for matnring salmon eggs that I have yet seen. It is simple, compact, and effective. By means of it we hatched 18,000 eggs to the snperficial foot of hatching-troughs without the least difficulty; so that in one length of our hatching-troughs of 80 feet we matured 1,500,000 salmon eggs.

The rack just mentioned made the best kind of inelosure for the breeding salmon, enabling us to dispense with all the pens and pounds, etc., which eaused so much trouble and disappointment the previous year.

The report continues:

When the salmon had made an nnsuccessful assault upon the dam, they fell back into the hole at the foot of the rapids, which formed the lower fishing-gronnd. Here they were practically in as secure eonfinement as if they had been caught and placed in a ponnd, for the dam prevented them from going upstream, and their irrepressible instinct to ascend the river prevented them from going down. Every foot of this hole was swept by the seine. No better corral or inclosure for confining the fish could be constrncted. Here they had their natural habitat and surroundings, the whole volume of McCloud River for a water-snpply, and nothing whatever to prevent them from keeping healthy and in first-rate condition. It was the best possible kind of a pound for them. Last year they lashed themselves to pieces trying to escape from their artificial pens. This year they kept as fresh and well as could be wished. They accumulated in this hole by thousands. When any were wanted, it was only necessary to extend the net aronnd them and haul them in. Once or twice no less than 15,000 pounds of salmon must have been inclosed in the net. They formed a solid mass, reaching several yards from the shore, and filling the net 2 or 3 feet deep. If I should say 20,000 pounds, I do not think it would be exaggerating.

This year the station graduated from its experimental stage, and from this time forward was recognized as a permanent station of the Fish Commission.

The next year, 1875, and the subsequent years previous to 1883, the main features of the work of the station having been settled, operations were conducted on the same lines as in 1874, the chief desiderata now being to increase the efficiency of the station and to reduce the pro rata expense of procuring and distributing the eggs.

The story of the happenings at the station consequently now become less interesting, but a few important events may be worth mentioning.

The prominent feature of the season of 1875 was the abundance of spawning salmon in the McCloud. They were so thick in the river in July that we counted a hundred salmon jumping out of the water in the space of a minute, making 6,000 to be actually seen in the air in an hour. Nearly 9,000,000 eggs were taken, and there were more to be had for the taking. The following statistics may be interesting:

There were in bulk almost 100 bushels of salmon eggs. To mature these eggs 1,200,000,000 foot-pounds of water were pumped from the river by the wheel-pump. It took 160 bushels of moss from Mount Shasta and over 800 yards of mosquito-bar to hatch the eggs. When packed, they filled 158 boxes 2 feet square by 6 inches deep. It took 79 crates, containing 2 boxes each, to hold the eggs. The whole lot of eggs sent east weighed, when packed, 20,000 pounds, and the express charges paid Wells, Fargo & Co. were about $3,000.

It was in this year (December 9, 1875) that 280 acres of land on the McCloud, including the station of the United States Fish Commission, were set aside by President Grant as a government reservation.

The first consignment of salmon eggs was sent across the equator to Australia and New Zealand this year. This was a very trying trip for salmon eggs, which can not survive a temperature of over 70° or 75° F., and which would hatch out in 10 days' journey at 60° F. The journey to Australia, however, was very successful, and, consent having been obtained to place the eggs in the ship's ice room during the voyage from San Francisco to Auckland, the eggs arrived in Australia in fine order.

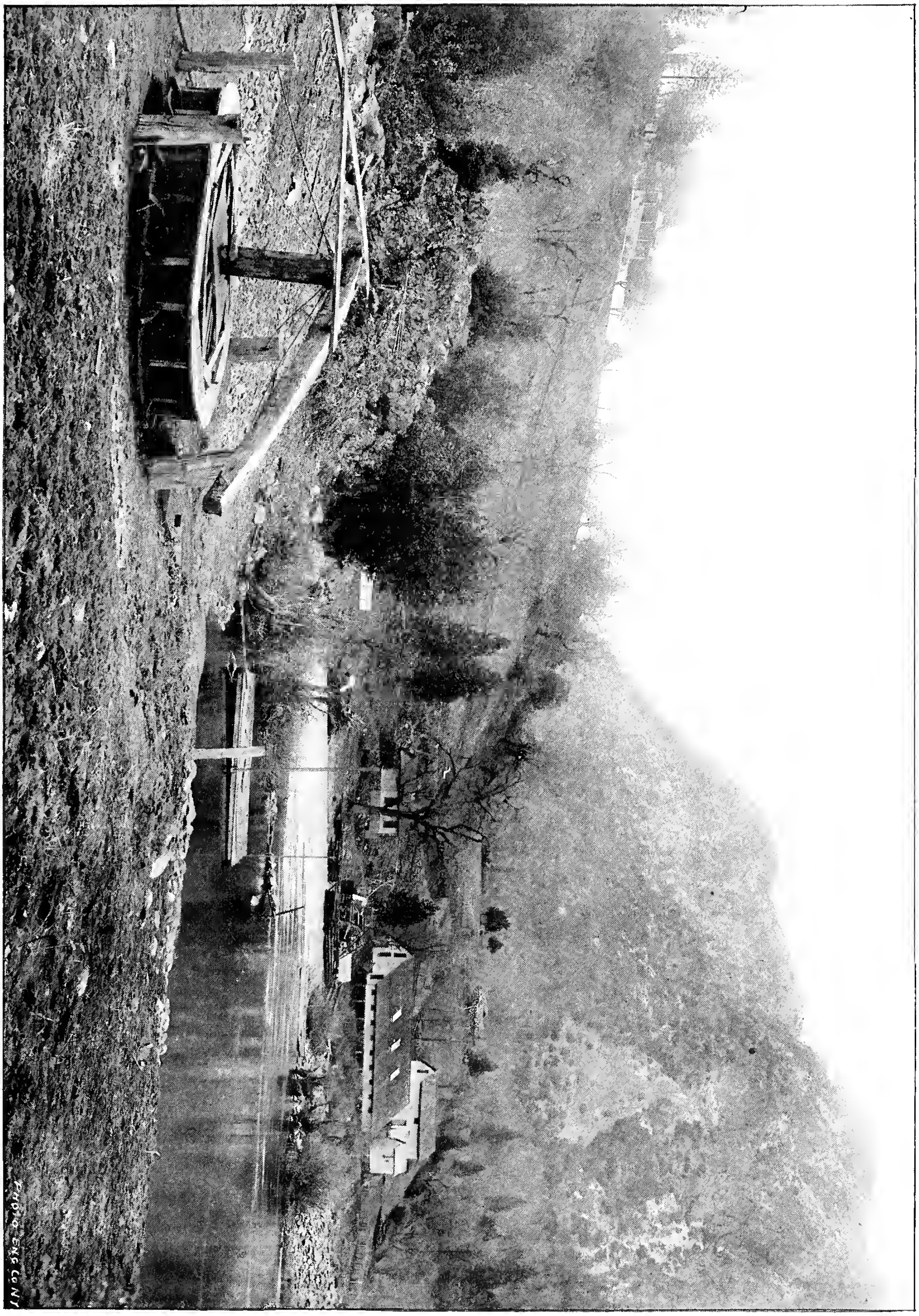
Some salmon eggs were hatched at the station this year and the young fish planted in tributaries of the Sacramento.

Among the events of 1876 at the station, the building of the hatching-house should be mentioned, because previous to this year the hatching-troughs had all been under a huge tent. This year the tent was dispensed with, and a large and very substantial hatching-house was erected. Much progress had been made also in spawning the salmon and in packing the eggs for shipment, as is shown by the facts that 1,000,000 salmon eggs were taken in a single day, September 4, and that we succeeded in packing, for a long journey, 400,000 eggs in 1½ hours.

As an illustration of the effect upon the salmon-ova market of the operations of the United States Fish Commission in taking salmon eggs, I will mention the striking fact that "five years ago the United States paid the Canadians $40 per 1,000, in gold, for salmon eggs, and now the United States Fish Commission is sending salmon eggs from California to the British Colonies of the Pacific for 50 cents per 1,000, being a reduction of price in the ratio of 80 to 1."[1]

In 1876 the practice was inaugurated of shipping the eggs for eastern consignees all together in a private ice car as far as Chicago, and distributing them from there to their various destinations by express.

[1] United States Fish Commissioner's Report 1875-76, page 943.



SEINING GROUND AT THE LEFT; HATCHING HOUSE AND OTHER BUILDINGS AT THE RIGHT. SUPERINTENDENT'S RESIDENCE IN THE BACKGROUND
BAIRD STATION, McCLOUD RIVER.

Prof. Baird, in his report to Congress, speaks as follows in regard to this method:

After careful consideration, Mr. Stone advised that all the eastern shipments of eggs in 1876 should be made in bulk as far as Chicago, and that a special car should be secured and properly fitted up, in which the eggs should be placed and transferred on an express train in the care of proper messengers. This experiment was carried out and proved an entire success, 18 consignees in 13 States receiving their supplies in even better condition than usual and at less expense.

The foreign demand for ova had increased to such an extent by 1877 that during that year salmon eggs were sent from the McCloud to Prussia, Germany, the Netherlands, England, France, Canada, Australia, and New Zealand. The experience acquired in packing and shipping the eggs enabled us this year to get them to their destinations with very slight loss in transit.

The *Lyttleton Times*, Christ Church, New Zealand, of November 14, 1877, says:

The *splendid condition* in which the Wellington consignment of American salmon ova has arrived reflects great credit on those in America who had charge of the collecting and packing, which in several respects is an improvement on the English method.

The War Department furnished the station a military guard this year, which proved to be a very valuable acquisition.

The hatching of a large portion of the salmon eggs for the State of California continued during this year and subsequent years until 1884. The year 1878 was the year of the immense gathering of salmon in the McCloud. Regarding this extraordinary appearance, my report for 1878 reads:

I have never seen anything like it anywhere, not even on the tributaries of the Columbia. On the afternoon of the 15th of August there was a space in the river below the rack about 50 feet wide and 80 feet long, where, if a person could have balanced himself, he could actually have walked anywhere on the backs of the salmon, they were so thick. I have often heard travelers make this remark about salmon in small streams, so I know that it is not an uncommon thing in streams below a certain size, but to see salmon so thick as this in a river of so great volume as the McCloud must, I think, be a rare sight. About this time I kept a patrol on the bridge every moment, night and day, and this precaution, though an expensive one, was well rewarded, for this vast number of salmon continually striking the bridge with sledge-hammer blows were sure, in the course of time, to displace something and effect a passage through to the upper side, and when one did succeed in getting through, the others would follow with surprising rapidity, one after another, like a flock of sheep going through a break in a fence. This swarm of salmon just alluded to remained at the bridge and kept up the attack at one point or another for three days, and then fell back to the pools below, where, with occasional renewals of their attacks, they remained until they were caught in the seine.

The spawning season began the 20th of August, with the taking of 30,000 eggs from 7 fish. Every haul of the net brought an enormous quantity of salmon. Without our trying to capture many, the net would frequently bring in a thousand at a haul. We found very few ripe fish, however, until the 28th of August, when the spawning season set in in good earnest, and from this date to the last day of taking eggs the yield was very large and remarkably regular.

This leads me to say that the most extraordinary feature about the fishing season this year was that the salmon in the river did not seem to be diminished by our constant seining. We made enormous hauls with the net every day, spawned a large number of salmon, and gave a large number to the Indians for their winter supply, but always the next day the spawning salmon seemed to be as thick as ever. This abundance of salmon was a daily surprise to everyone. Every day we were regularly, though agreeably, disappointed. It was three weeks before we made any impression on the spawners in the river. At last, about the 15th of September, the females with spawn began to fall off a little, but only a little. We had enough eggs by this time, however, and stopped fishing on the 18th of September, not because of any scarcity of salmon, but because we did not want any more eggs. We had in the hatching-house, on the evening of that day, 12,246,000 salmon eggs, according to our record count, though without doubt 14,000,000 in reality, as our method of counting purposely left a large outside margin for emergencies. Had we continued to fish and take eggs till the close of the fishing season we could probably have taken 18,000,000 eggs, and perhaps more.

One of the ways employed for increasing the catch of breeders is so peculiar that perhaps a description of it may not be out of place here:

As may be readily supposed, the constant drawing of the net over the seining-hole had the effect of frightening the salmon off the ground. Of course it was necessary to get them back again before they spawned, as otherwise we should have lost the eggs. This year I accomplished it in this way: I had several Indians go up to the bridge armed with long poles. At a given signal three Indians jumped into the foaming rapids below the bridge, and by splashing the water with their arms and limbs and making as much of a disturbance in the water as possible, did everything they could to frighten the salmon out of the rapids. On reaching the deep holes, where the fish lay collected by hundreds and perhaps thousands, the Indians dove down in the very midst of the swarms of salmon, and, stirring them up with their long poles, succeeded in driving them out.

On these occasions the hauling of the seine was quite an exciting event. The Indian swimmers, their dark heads just showing above the white foam, screaming and shouting in the icy waters and brandishing their long poles, came down the rapids at great speed, disappearing entirely now and then as they dove down into a deep hole. As soon as they approached within about 4 rods of the fishing skiff, the boat shot out from the shore, the second boatman braced himself and his oars for a quick pull down along the bank, the man at the stern of the first boat began paying out the seine, the fishermen on the beach gathered at their respective ropes, the men on shore began throwing rocks in the rapids, and in a few moments the net was drawn to the beach with an enormous mass of struggling, writhing salmon, often weighing in the aggregate not less than 4 or 5 tons. Then the fishermen sprang into the water and examined the fish, taking the ripe ones to the corral and throwing the unripe ones back into the river until the net was emptied. Then all was quiet again and the men proceeded to take the eggs from the ripe salmon which they had captured.

This year, in packing eggs, we averaged 500,000 an hour:

Had not the character of the packing, as shown by the way in which the boxes were finally opened, been made the subject of unusual commendation from the parties who were engaged in unpacking the eggs at their destination, I should hardly venture to say how rapidly they were packed, lest it might be thought to imply undue haste or want of care. I will, however, under the circumstances, state that the eggs were actually packed at the rate of 500,000 an hour, and I will add my own testimony also, that I never saw eggs packed with more care, fidelity, and pains, the rapidity with which the work was dispatched being wholly the result of experience and skill and the enthusiasm with which everyone employed did the part of the work which fell to his share.—(United States Fish Commissioner's Report, 1878, page 762.)

We had an Indian scare this year and the War Department sent us rifles and ammunition. It was extremely unpleasant for a few weeks at the station, but it resulted in no actual injury. It will be remembered, perhaps, that during the previous year a gigantic plan had been arranged for the universal uprising of all the Indian tribes between the Missouri on the east and the Cascade Range and the Sierra Nevadas on the west. This came very near being successful, and if it had not been broken up, as it was, by the vigilance and activity of the United States troops it would have resulted in widespread calamity in the sparsely settled regions of the West. Fortunately, General Howard gave it a deathblow in the capture of Chief Joseph and his band near the Missouri, but the infection spread as far west as McCloud River, and for a few weeks rendered life there anything but agreeable.

In 1879 the experiment was tried of putting two sacks across the McCloud, one above the seining-ground, wholly closed to the salmon, of course, and one below the seining-ground, partly open at the bottom. It was thought in this way that more breeding salmon would remain on the seining-ground, but it was not a success and the results did not warrant a renewal of the experiment. We had a military guard at the station this year, and the presence of soldiers was found very useful, but they were not needed this season for protection from the Indians, who had become quiet again

and had almost dropped entirely their hostile demonstrations of the previous year. No trouble will ever be experienced here again from the Indians as a body. The gradual disappearance of the natives has contributed to this result, and railroads and white settlements have done the rest.

It was during this year that the McCloud River trout-breeding station was established in connection with the salmon station at Baird, from which station have emanated almost all the rainbow trout (*S. irideus*) which have now become so generally distributed over this country and Europe. The other trout of the McCloud River are the Dolly Varden (*Salvelinus malma*) and a new species, the no-shee, first described by Dr. Jordan as follows:

Description of the no-shee trout (Salmo gairdneri stonei), a new subspecies of trout from McCloud River.

Salmo gairdneri stonei subsp. nov.

Allied to the form called *Salmo irideus*, but distinguished by its small scales, the number of scales in a transverse series being about 155, 82 before dorsal, where they are small and imbedded, 25 above lateral line. Teeth fewer and smaller than in var. *irideus*, those on the vomer in a single zigzag series. Axillary scale of ventral small. Pectoral 1⅓ in head. Eye large, 4½ in head. Maxillary two-tenths. Upper part plain greenish. Spots small and sparse on dorsal, adipose fin, and caudal; a few spots only on posterior part of the body. A faint red lateral band; cheeks and opercles with red; no red between branches of lower jaw. Depth 4 in length. Anal rays 11. Described from a specimen 14 inches in length, collected by Livingston Stone, in McCloud River, at Baird, Cal.

This form is well known to the Indians and to the fishermen on the Upper Sacramento. According to Mr. Stone, the Indian fishermen say that it is abundant in the McCloud River, about 8 miles above Baird. They are larger in size than the ordinary *irideus*, one having been taken weighing 12 pounds. Named for Livingston Stone, director of the United States fish-hatchery at Baird.

Nothing of special interest occurred in 1880, but the next year, 1881, was made memorable by the extraordinary rise in McCloud River, which carried away almost the entire station in one night:

The month of January was attended by a rainfall wholly unprecedented[1] in northern California since its settlement by white men. Forty-seven inches of water fell in Shasta during this month, and in the mountains where the fishery is situated the fall must have been much greater. On the 27th of January the McCloud had risen 12½ feet, but the water had been higher than that in previous years, and still no one supposed that the buildings were in danger. Again the river fell, but this time the fall was succeeded by the greatest rise of water ever known in this river before, either by white men or Indians now living. During the first days of February the rain poured down in torrents. It is said by those who saw it that it did not fall as rain usually falls, but it fell as if thousands of tons of water were dropped in a body from the sky at once. Mr. J. B. Campbell relates that near his house, in a canyon which is dry in summer, the water in not many minutes became 30 feet deep, and the violence of the current was so great that trees 100 feet long were swept down, trunk, branches, and all, into the river. On the 2d of February McCloud River began to rise at the rate of a foot an hour. By 9 o'clock in the evening it was 16⅔ feet above its ordinary level. The water was soon a foot above the danger mark, and the buildings began to rock and totter as if nearly ready to fall. There was now no hope of saving them or anything in them. At 2.30 a. m. February 3 they toppled over with a great crash, and were seized by the resistless current and hurried down the river.

When the day dawned nothing was to be seen of the main structures which composed the United States salmon-breeding station on the McCloud River. The mess-house, where the workmen had eaten and slept for nine successive seasons, and which contained the original cabin, 12 by 14 feet, where the pioneers of the United States Fish Commission on this coast lived during the first season of 1872; the hatching-house, which, with the tents which had preceded it, had turned out 70,000,000 salmon eggs, the distribution of which had reached from New Zealand to St. Petersburg; the large dwelling-house,

[1] Rainfall at Shasta: January, 1881, 47 inches; February, 1881, 17.5 inches; total for the season, 109.7 inches.

to which improvements and conveniences had been added each year for five years—these were all gone, every vestige of them, and nothing was to be seen in the direction where they stood except the wreck of the faithful wheel which through summer's sun and winter's rain had poured 100,000,000 gallons of water over the salmon eggs in the hatchery, and which now lay dismantled and ruined upon the flatboats which had supported it, and which were kept from escaping by two wire cables made fast to the river bank. The river continued to rise the next forenoon until it reached a maximum height of 26⅔ feet above its summer level. This, of course, is not a very extraordinary rise for a slow river; but when it is remembered that the McCloud is at low water a succession of cascades and rapids, having an average fall of 40 feet to the mile, it will be seen at once what a vast volume of water must have been poured into this rapid river in a very short time, and with what velocity it must have come, to have raised the river 26 feet when its natural fall was sweeping it out of the canyon so swiftly. Those who saw this mighty volume of water at its highest point, rushing through its mountain canyon with such speed, say that it was appalling, while the roar of the torrent was so deafening that persons standing side by side on the bank could not hear each other when talking in an ordinary tone of voice.

It must be over two centuries since McCloud River rose, if ever, as high as it did last winter. There is very good evidence of this on the very spot where the fishery was located, for just behind the mess house, and exactly under where the fishery flag floats with a good south breeze, is an Indian graveyard, where the venerable chiefs of the McCloud have been taken for burial for at least two hundred years, and there is no knowing how much longer. One-third of this graveyard was swept away by the high water last winter, and the ground below was strewn with dead men's bones. Now, the fact that the Indians have been in the habit of burying their dead in this spot for two centuries proves that the river has never risen to the height of last winter's rise within that time, for nothing could induce the Indians to bury their fathers where they thought there was the least danger of the sacred bones being disturbed by the floods.

When the waters subsided it became apparent what a clean sweep the river had made. Here and there the stumps of a few posts, broken off and worn down nearly to the ground by driftwood rubbing over them, formed the only vestiges whatever to indicate that anything had ever existed there where the station stood but the clean rocky bar that the falling water had left.

The writer, at the direction of Professor Baird, proceeded immediately to rebuild the station, under a special appropriation made by Congress for that purpose. The entire cost of the new station, including the expense of taking the season's salmon eggs (7,500,000), was $15,000.

The only accident that ever occurred to the current wheel during the egg-taking season happened this year, but it was properly repaired, and owing to the really magnificent help of the Indians, who worked incessantly for seventeen hours, no losses occurred to the eggs. The breeding salmon appeared in the river in great numbers, making it necessary to take eggs during only about half the season.

Nothing of special interest happened in 1882, but in 1883 great dismay was caused by the nonappearance of the salmon in the upper tributaries of the Sacramento. The Southern Pacific Railroad Company had begun building its line from Redding north toward Oregon, and during the summer had reached the mouth of Pitt River, about 8 miles below Baird station. It is said to be the custom of this company to employ a great deal of gunpowder and dynamite for making excavations, and they had used these explosives to such an extent at and below the mouth of Pitt River that the breeding salmon coming up the river to spawn either could not get by where the blasting was going on or were killed outright by it. At all events, salmon were very scarce in the McCloud, and less than a million eggs were secured this season, and these only with great difficulty.

Owing to the destruction of the salmon by the railroad workers,[1] Professor Baird

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[1] We were told that there were 6,000 workmen, white men and Chinamen, employed in the vicinity of Pitt River in building the road.

discontinued operations at the salmon-breeding station on McCloud River in 1884, and they were not renewed till 1888, when the writer was made field superintendent of the Pacific Coast, and instructed by Hon. Marshall McDonald, then United States Commissioner of Fish and Fisheries, to push vigorously the salmon-breeding work on this coast. The writer reopened Baird station in the spring of 1888, and leaving Mr. George B. Williams, jr., in charge as temporary superintendent, proceeded to Oregon to carry out the instructions of the Commissioner to secure for the United States the salmon-breeding station on Clackamas River, Oregon. This station, which the writer built for the Oregon and Washington Fish Propagating Company (cannery owners on the Columbia) in 1877, was still owned by them, but had been leased to the State of Oregon. The company at first wanted $10,000 for the station, but after several weeks of consulting and negotiating they consented to deed the place to the United States for nothing, and the Oregon commissioners gave up their lease on the reimbursement to them by the United States of the actual cost of improvements they had just made. The transfer was practically made July 1, 1888, on which day the splendid salmon-breeding plant on Clackamas River became a station of the United States Fish Commission.

Upon the writer's recommendation Mr. Williams was confirmed as permanent superintendent of Baird station, and held that position from 1888 to July, 1892. During this time an average of 3,000,000 salmon eggs was taken annually and various improvements made to the station, including the construction of a "winter-quarters building," which has always been used since for the superintendent's residence.

In August, 1892, on the resignation of Mr. Williams, the writer resumed charge of Baird station. Not much was accomplished that year, but the next year, 1893, nearly 8,000,000 eggs were taken. The next year, 1894, owing to very unexpected high water in October the number of salmon eggs collected dropped to about 4,500,000, but the next year, 1895, the number rose again to nearly 10,000,000, breaking the record of this station for every previous year except the extraordinary season of 1878, above mentioned.

Of these last few years, the work having fallen into specified grooves, there is very little to relate, one season being very much like another. One thing, however, which promises to be very useful to the station in the future, as well as a saving of expense, deserves mention, and that is the construction of a ditch for bringing the water supply by gravity to the hatching-house during the fall run of salmon.

It is dangerous to use the current wheel in the fall, and it is expensive to run the engine. The ditch does away with both, and as it requires no watching in good weather it saves the expense of a night watchman. The ditch takes the water from Wiley Creek at a point about 1¼ miles from the hatching-house, and up to this time has worked admirably, which is all the more encouraging because an irrigating ditch grows safer and more reliable every year it is used.

It should be mentioned here that, while at first, from 1872–1883, inclusive, Baird station was operated chiefly for other waters of the United States, now it is almost wholly operated for the benefit of the Pacific Coast, as the distribution this year, 1895–96, will show.

Perhaps this account of Baird station ought not to be concluded without a brief reference to a station of the California State Fish Commission, which may possibly pass very soon into the charge of the United States. This station is situated on a

small tributary of the Sacramento called Battle Creek, and is about 7 miles from the town of Anderson, in Shasta County, though it is itself just over the Tehama County line. This Battle Creek is the most extraordinary and prolific place for collecting quinnat-salmon eggs yet known, though the eggs are limited to the fall run of salmon, as none worth mentioning of the summer run of fish ascend Battle Creek. The first salmon make their appearance early in the fall, and before November and during that month they are found in almost incredible numbers in the wide lagoon extending about $2\frac{1}{2}$ miles up the creek from its mouth. I am well aware that fish-culturists' predictions are generally overdrawn and consequently disappointing in the end, but it seems to me safe to say that 20,000,000 salmon eggs can be taken on Battle Creek in six weeks of a favorable year; 10,000,000 eggs were actually taken there in three weeks last year, and the California Fish Commission only stopped then because their hatching-house was filled. Battle Creek will not produce eggs of the summer-run salmon, but it will yield an almost unlimited number of fall-run eggs, until unfavorable conditions prevent the breeding salmon from ascending the stream.

To return to the Clackamas station, in Oregon, I will say that unfavorable conditions have already set in there and seriously interfered with the operations of the station. When it first passed into the hands of the United States Fish Commission it yielded 5,000,000 salmon eggs a year, but it was too near civilization to prosper long as a salmon-breeding station, and gradually mills and dams, timber cutting on the upper waters of the Clackamas, and logging in the river, together with other adverse influences, so crippled its efficiency that it was given up this year as a collecting-point for salmon eggs, but several million eggs have been sent there from Baird station and Battle Creek, so that a very respectable number of salmon eggs will doubtless be hatched for the benefit of Columbia River this season.

I may add here that several attempts have been made to discover and establish salmon-breeding points in the basin of the Columbia, but none has been found sufficiently productive to warrant their continuance. Some effort also has been made to secure quinnat-salmon eggs from the smaller California streams flowing into the Pacific Ocean, but no great success has been attained there yet, although many quinnat and steelhead eggs have been secured and favorable results obtained, notably at Fort Gaston station and its branches, in acclimatizing several species of the *Salmonidæ* not indigenous to this coast.

The question now naturally arises, What are the results of all this great labor and expenditure extended over so many years? Allow me to reply as follows:

When the work of the United States Fish Commission in salmon breeding was begun on the Pacific Coast, it was supposed that that coast had enough salmon to spare, and it was the intention of the Commission to increase the salmon on the Atlantic Coast by restocking its depleted salmon rivers. The highest hopes were entertained of doing this. After it had become an accomplished fact that millions of salmon eggs had been procured on this coast, and that they had been safely transported across the continent to the Atlantic rivers, I doubt if there was one person who had heard about it in America, whether interested in fish-culture or not, who did not believe that salmon were going to become abundant again in the Atlantic rivers on account of the introduction of the Pacific Coast fish; and not only this, but many persons believed that several southern rivers that had never had salmon in them before, would now become prolific salmon streams, when they were well stocked with

this new California salmon that abounded in warm latitudes on the Pacific Coast. That this did not prove to be the result was a stupendous surprise and disappointment. The eggs hatched out beautifully. The young fry, when deposited in the fresh-water streams seemed to thrive equally well. They grew rapidly and when the proper time came were observed to go down in vast numbers to the sea. What afterwards became of them will probably remain forever an unfathomable mystery. Except in very rare isolated instances, these millions of young salmon were never seen again. What became of them? Where did they go? Are any of them still alive anywhere in the boundless ocean? Or are they all dead? And if they are dead, what killed them? Much as this information has been desired, there lives no one who can answer these questions. Some have thought that they wandered off to the far North, and so became lost to the civilized world. Others thought that they strayed out into the ocean and were devoured by marine animals and larger fish. Professor Baird once jokingly remarked to the writer that he thought they had found an underground passage beneath the continent, and had returned by it to the Pacific. One thing is certain, and that is that these millions of salmon have disappeared as completely from the Atlantic Ocean[1] and its tributaries as if they had all been devoured years ago by the monsters of the deep.

Referring to this unaccountable and disheartening fact, Hon. Marshall McDonald, United States Fish Commissioner, said, in his report for 1888—

These[2] experiments [stocking Atlantic rivers with California salmon] were undertaken on a scale unprecedented in the history of fish-culture. Millions of eggs were transferred to the eastern stations, hatched out, and the fry planted in nearly every one of the larger rivers south of the Hudson. In no single case did the experiment prove satisfactory, and the Commissioner was forced reluctantly to abandon an experiment which, reasoning from *a priori* considerations, gave fair promises of success, and which, had it succeeded, would have given us a new and valuable fishery in the Atlantic rivers.

This, however, is only one side of the case. As soon as the requisite space of time had elapsed after the United States Fish Commission began to return young salmon fry to the Sacramento, the fishes of that river showed a great increase. New canneries sprang up every succeeding year. The market for fresh and salted salmon in San Francisco felt the effects of the salmon-breeding work on the McCloud.

The following interesting statement appears in the United States Fish Commissioner's Report for 1882, page 840:

One of the last official acts of the late Hon. B. B. Redding, as California fish commissioner, before he died, was to write a letter to Professor Baird in regard to this station, in which he stated that several hundred thousand dollars had been invested in canneries on the Sacramento River, and that this capital and these men would be ultimately thrown out of employment if the salmon hatching at this station should be given up. He also stated that the hatching of salmon here had increased the annual salmon catch on the Sacramento 5,000,000 pounds a year, and that the canneries on the river were dependent upon the salmon hatching of this station for their maintenance.

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[1] *Per contra* of the above: I have been recently informed that eggs are now being taken in France from quinnat-salmon breeders that were raised from eggs originally sent from Baird station. The *Pittsburg Dispatch*, January 13, 1896, makes the following statement:

"*California salmon in France.*—French newspapers a few weeks ago contained the announcement that a magnificent California salmon (*S. quinnat*), measuring 3½ feet in length, had just been taken in a pond in Landernau, Brittany, having been bred by the mayor of that town from spawn procured from the Trocadero aquarium. The flesh is described as most delicious; its color is not mentioned. This was followed by the capture of several smaller specimens. It has also been stated that a fish of the same species, weighing over 12 pounds, was caught last April at the city of Montereau. The editor rejoices that this matchless breed of salmon has now been acclimated and probably will soon abound in France."

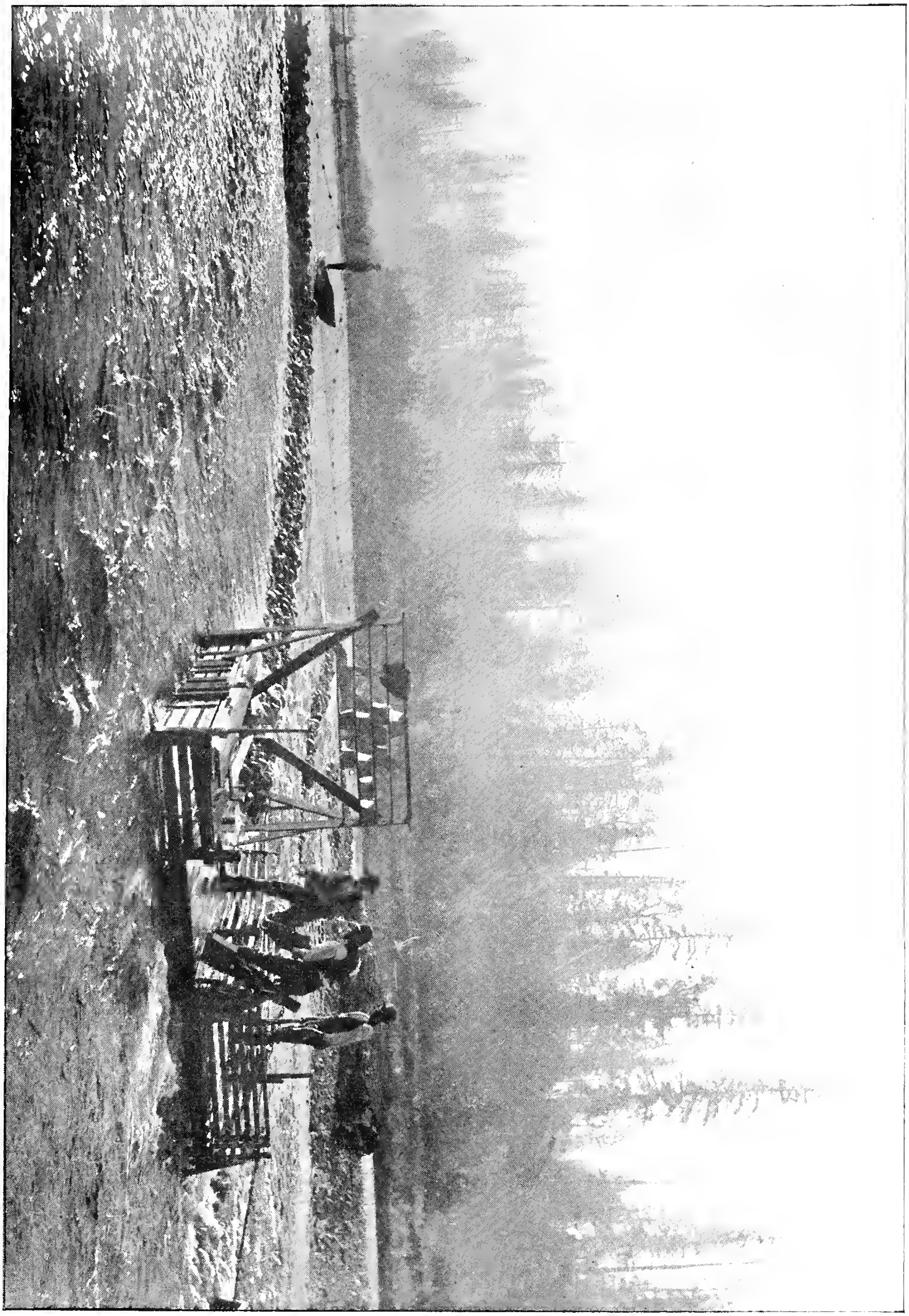
[2] United States Fish Commissioner's Report, page xxxv, for 1888.

It thus appears that although nature has evidently designed that the quinnat salmon shall not take up its abode on the American shores of the Atlantic, the breeding of this fish seems to serve a legitimate and very valuable purpose in keeping up the supply of its species in its native waters of the Pacific Slope; especially in view of the enormous drafts made upon these fish by the canneries and by the yearly increasing consumption of fresh and salted salmon.

The prospect for the immediate future at Baird station is very promising. To begin with, it has a valuable and very efficient plant in the way of buildings, apparatus, etc. At the upper or northern end of the station there is a large fenced corral or pasture for horses and cattle, and inclosed in this corral is a convenient stable and storehouse. Just below there is the hatching-house, with a capacity of 10,000,000 or 12,000,000 salmon eggs. Then comes the engine house, with a good steam engine and pump. A few rods below are the foreman's residence and the comfortable and commodious mess house, and nearly adjoining a store and post-office and the residence of the postmaster. Other smaller structures near the seining-ground complete the list of buildings at the station, with the exception of the superintendent's residence on a hill 100 feet above, which overlooks all or nearly all the other buildings; and last, but not least, a ditch 1½ miles long brings water from a neighboring creek into the hatching-house. The station has still, as it always had, the hearty good-will and cooperation of the California State Fish Commission, which alone is a most valuable aid to its efficiency.

Salmon are now very abundant in the Sacramento and McCloud, and are on the increase. The situation of the station and its adaptability to its purpose are almost ideal. McCloud River, on the banks of which it stands, is not only cold, clear, and very inviting to the salmon, but it is almost the only cold tributary of the Sacramento that has not been roiled by gold mining, in consequence of which the salmon come into the McCloud to breed in the summer, not only from choice, but also from necessity. The geological formation of the land about the river is not favorable for gold, which probably insures its safety indefinitely from gold miners.

It is also an Indian country. There is not a white family on the McCloud from its mouth almost to Mount Shasta, except those who live at the station and at the old trout-pond station of the Fish Commission. Furthermore, most of the land in the McCloud Canyon is unproductive, which is another protection against the advent of white men, and as long as white men keep away from the river the salmon in it will retain their primeval habits and abundance. The station also is situated in a United States reservation, which secures it from intrusion by land-jumpers or evil-minded people who might interfere with the salmon and salmon fishing. And, what I must not forget to add, it is located just at the junction of McCloud River and the California and Oregon stage road, which places the station, though in one of the wildest parts of California, in immediate touch with the civilized world. All these advantages make this station an ideal place for its purpose, and bespeak for it, for many years to come, an efficient and useful career. And it can be further said of this station, with justifiable pride, that after a quarter of a century's service it still remains the only station in the United States that can produce every year a satisfactory quota of eggs of the summer run of quinnat salmon.



DRIVING SALMON INTO THE TRAP, CLACKAMAS STATION, OREGON.

METHODS EMPLOYED BY THE UNITED STATES FISH COMMISSION ON THE PACIFIC COAST FOR CAPTURING BREEDING SALMON, TAKING AND SHIPPING THE EGGS, ETC., WITH SPECIAL REFERENCE TO BAIRD STATION, CALIFORNIA.

CAPTURING THE BREEDING SALMON.

The first Pacific Coast salmon captured in the United States for breeding purposes were caught in an Indian "basket trap," on McCloud River, in 1872. The reason that they were taken in this way was because there had been no time for making preparations for catching the salmon in any other way, the writer, who had been commissioned by Professor Baird, United States Commissioner of Fish and Fisheries, to procure eggs of these salmon, having arrived on the McCloud just in the midst of the spawning season. Professor Baird's report for that year reads as follows:

> The propriety was strongly urged at the Boston meeting of sending some experienced fish-culturist to the west coast for the purpose of securing a large amount of spawn of the California salmon. At the suggestion of the meeting, Mr. Livingston Stone was engaged to undertake this work, and proceeded to California as soon as he could arrange his affairs for the purpose. The experiment was, of course, uncertain, in the entire absence of any reliable information bearing upon the natural history of the species. It was not even known at what period they spawned, although Mr. Stone was assured by professed experts, on his arrival in California, that this occurs late in the month of September.
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> After much fruitless inquiry, Mr. Stone at last learned, chiefly through Mr. B. B. Redding, fish commissioner of California, and through the chief engineer of the Central Pacific Railroad, that the Indians speared salmon on McCloud River, a stream of the Sierra Nevada, emptying into Pitt River 320 miles nearly due north of San Francisco. Proceeding to this station, in company with Mr. John G. Woodbury, of the Acclimatization Society, Mr. Stone immediately set to work in erecting the necessary hatching establishment, although, on account of the distance from any settlement and the absence of special facilities, he found the undertaking both difficult and expensive. The efforts of Mr. Stone and his party were prosecuted unintermittingly, day and night, for a sufficient length of time to prove that the season had almost entirely passed and that but few spawning fish remained.

The basket trap above mentioned consists of a partial obstruction across the river, made of wickerwork, in form having a general resemblance to the letter V, with the angle downstream. At the apex of the angle is a wicker basket, from which, if the fish fall into it, they can not escape. It should be mentioned here that after the breeding salmon ascend the river to spawn, they fall back after spawning, and gradually float, tail first, down the river, though occasionally they fall back in this way before spawning. These traps are put across the river by the Indians in order to capture the salmon, without, of course, any regard to the eggs they may contain. Fortunately, after the arrival of the writer on the McCloud, a few salmon that had not spawned fell into these traps, and for a slight money consideration given to the Indians the fish were obtained and their eggs secured for maturing.

As soon as circumstances rendered it practicable, a seine was procured and seining was begun in regular form in McCloud River; and from that time till now this method of seining with a sweep seine has been the best and the only successful method of capturing the parent salmon in the McCloud. Several experiments, however, have been tried, which may be worth mentioning, perhaps, simply to show that they are not satisfactory.

One of these experiments was made at Baird station by using fyke nets, set in McCloud River. In a small stream without too strong a current this method might be employed advantageously, but in the rapid current of the McCloud, which, though not a wide stream, carries a large volume of water, the fyke-net experiment proved a complete failure.

One or more large wooden traps have almost every year been built into the rack which extends across the river, and at times, especially during a rain storm accompanied by a marked rise in the river, large numbers of salmon are taken, but at other times only a few, and at all times only a small percentage of spawners are captured in the trap. The trap is quite a valuable auxiliary to the seine, but it would be a poor dependence if relied upon exclusively, because, although it will secure a great many unripe fish, the ripe ones, which are the ones that are wanted, finding an obstruction in their way, settle back to the spawning-grounds below and remain there.

Large dip nets have been occasionally used at the Clackamas station, in Oregon, the fishermen standing on the rack at night and dipping below it. Toward the end of the season this method secures a considerable number of spawners, but it involves labor and expense, and after all it is an open question whether most of the spawners taken with the dip nets would not have been captured in the regular course of fishing

The following plan deserves a brief description, as it is, I think, unique among methods employed by fish-culturists for capturing salmon:

There not being any entirely satisfactory seining-grounds at the Clackamas station, and the river just below the rack being shallow, we resorted to the Indian method of fishing. The aversion of the salmon to heading downstream is well known, but when they are very much frightened (stampeded) they will turn around and rush downstream at their utmost speed. The Indians take advantage of this and build a dam of rock or wickerwork, or anything that will present an obstruction to the frightened fish. This dam is shaped like the letter V, with the angle downstream, and at the angle, of course, is a large trap, which they can easily enter but can not escape from. This method of capturing the breeding salmon was the principal one employed at the Clackamas, and it worked very satisfactorily.

At Baird station, before it became customary to put a rack every year across the river, the seine fishing was exclusively done after dark, and was usually kept up all night. Since the rack has been used the seine has been hauled more or less in the daytime, with perfectly satisfactory results. We generally begin fishing now about 4.30 a. m., and keep it up as long as the fishing warrants it. We begin again about 5 o'clock in the afternoon and continue as we do in the morning.

The seines used at Baird station are from 120 to 170 feet long, made of about 28-thread twine, with a 4-inch mesh and a 20-foot bag, tapering down to about 6 feet at the ends. The seines have to be double-leaded, on account of the powerful current of the McCloud.

METHODS OF SPAWNING THE SALMON.

All methods of spawning salmon are in general the same, as of course they must necessarily be. There are, however, some slight differences in details, chiefly in holding the parent fish and in the manner of impregnating the eggs.

Where there is plenty of help and the salmon of medium size, the most expeditious way of holding the fish seems to be for the man who spawns the female salmon to hold

the head of the salmon in one hand and to press the spawn out with the other, another person being employed meantime in holding the tail of the fish to keep it still. This is the method uniformly adopted at Baird station. On the Columbia, however, where the salmon are larger and more unmanageable, the "straight-jacket," as it is called, is used. This is a sort of trough, made the average length of the salmon and hollowed out to fit in general the shape of the fish. Across the lower end of the trough is a permanent cleat, and at the upper end a strap with a buckle. The fish, when manipulated, is slid into the trough, the tail going down below the cleat, where it is securely held, and the head being immediately buckled in at the upper end with the strap. The fish is now securely held, and is unable either to get away or do any damage by its flounderings, and the eggs can be pressed out at leisure. The straight-jacket is almost indispensable with very large salmon, and a great convenience when the operators are short-handed. This is the method that has been generally employed at Clackamas station.

There is one more method of holding the fish that ought to be mentioned, which can be adopted with medium-sized salmon, and which might be called the one-man method. By this method, the operator holds the head of the salmon tightly between his knees, and, keeping the tail of the fish still with one hand, he presses out the ova with the other. This is a good way where there are only one or two men to attend to the spawning.

IMPREGNATING THE EGGS.

As in holding the spawning salmon, so in impregnating the eggs, all methods employed by enlightened fish-culturists are, in their general features, the same, the main points to be secured in all cases being identical, viz, to keep the eggs perfectly dry till the milt is applied, and to use the utmost dispatch in causing the spermatozoa of the milt to mingle with the eggs after the eggs are expressed from the fish.

The eggs, when they first leave the fish, have such an active absorbing power that they will very rapidly absorb any liquid that they come in contact with, and if taken in water will absorb the water so quickly that most of them become filled with water before the spermatozoa reach them, or rather before they reach the micropyle. But while it is a singular fact that the spermatozoa of the milt will die in water in two to three minutes, a little water is necessary to stimulate them into efficient activity. Consequently, while the eggs should be taken perfectly dry, a little water should be added to the milt, but the instant this is done the slightly diluted milt should be poured on the eggs. If the eggs are taken in one pan and the milt in another, simultaneously, and mixed together the instant they are ready, a very high rate of impregnation may be secured.

In actual practice at this station, one pan only has been generally used, and a very good impregnation has been secured in that way, but with only one pan the manipulations must be made quickly, and the rule must be observed to take the eggs dry and to introduce the diluted milt almost simultaneously with the taking of the eggs.

To obtain a high rate of impregnation, these points must be secured:

(1) The eggs must be taken dry.

(2) The milt must be taken simultaneously with the eggs.

(3) The milt must be diluted with a little water.

(4) The eggs and milt mixed together instantly after the diluting of the milt.

After the eggs have been impregnated, it is the custom to pour more water in the pan in a few minutes, and then leave the eggs perfectly quiet until they separate, which in the water of McCloud River in September (52° to 53° F.) usually takes about an hour. It should be added that the pans of impregnated eggs are placed in a trough filled with river water to keep them from becoming too warm. After the eggs separate they are carefully washed from all particles of effete milt, and then carried in buckets to the hatching-house. Here they are measured and placed in the hatching-trays.

HATCHING THE EGGS.

At Baird station the Williamson troughs with deep trays have been used for hatching the eggs. This plan has been found to be, in the writer's judgment, the best thing yet devised for maturing salmon eggs on a large scale. The trays used are really wire-netting baskets, about 12 inches wide by 24 inches long, and deep enough to bring the top of the trays an inch or two above the water, which is 5 or 6 inches deep in the Williamson troughs in which they were placed. Into these trays we pour 2 gallons of salmon eggs at a time. This makes the eggs 12 or 15 tiers deep, and yet they suffer no injury whatever from being so piled up, one explanation of this being that the water all the time forcing its way up through the eggs loosens them so that they do not feel the weight of those above them, while at the same time it reaches every egg and furnishes a fresh supply of air to them all.

The advantages of this method are:

(1) The top of the tray or basket is out of the water and always entirely dry; consequently in handling them the hands are always dry.

(2) By tilting one end of the tray or basket up and down a little, or by lifting the whole basket and settling it gently back again in its place, the white eggs will be forced to the top. Consequently no feather is required in picking over the eggs, and thus the injuries very often inflicted with the feather are obviated.

(3) The top of the basket being above the water, the eggs can never run over the top nor escape in any way, which is a great advantage over the shallow trays.

(4) The whole thing is so simple that nothing simpler that answers the purpose can be conceived. There is no complication of parts. There is nothing, in fact, to look after or move but the basket itself.

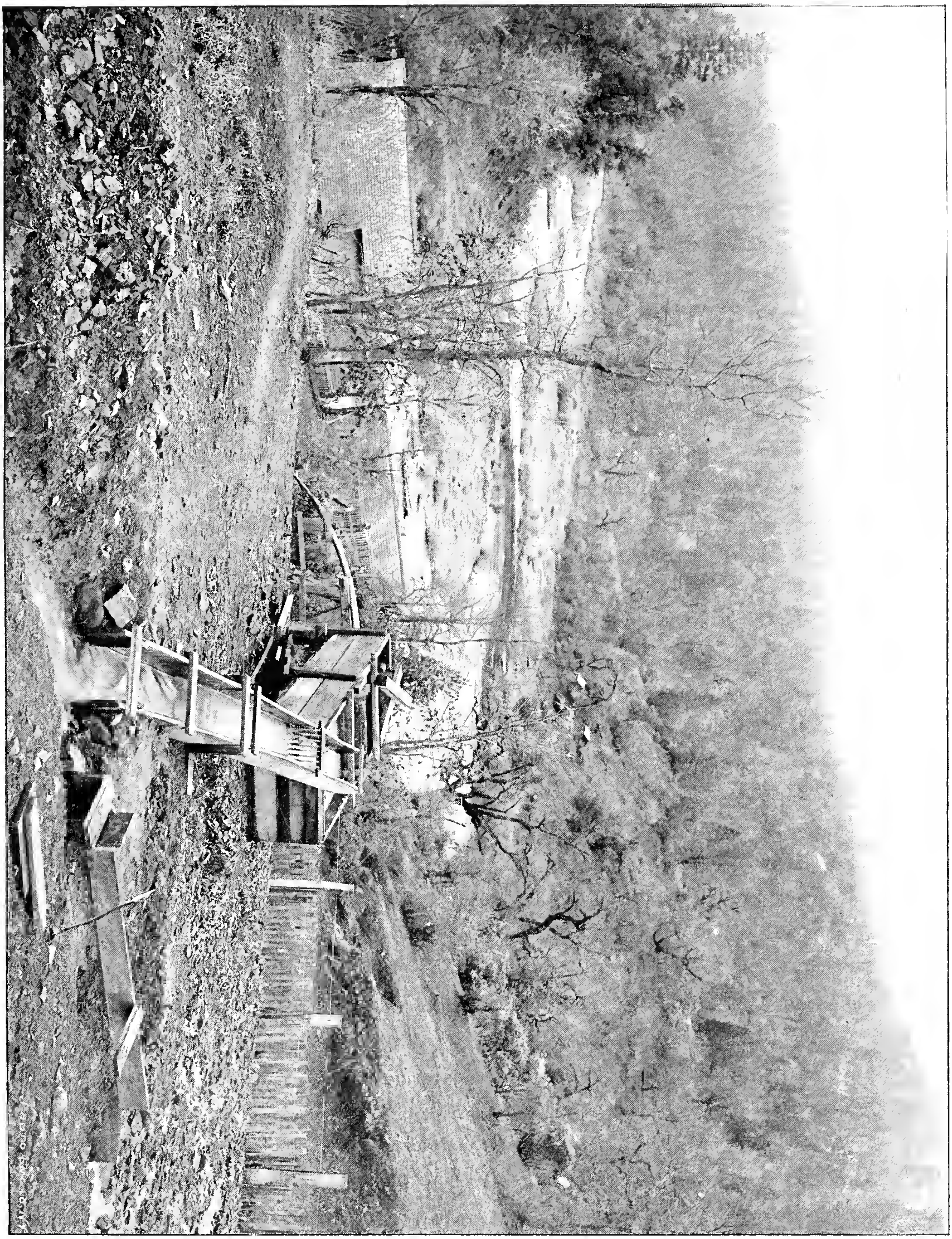
(5) Finally, it economizes space. Fifty thousand eggs can be kept on a superficial area of 2 square feet. Two troughs 20 feet long and 1 foot wide will, by this method, carry 1,000,000 salmon eggs.

The space in this trough, as in other hatching-troughs, is divided into compartments a trifle longer than the trays that are used to contain the eggs. The peculiar feature of the trough is that at the lower end of each compartment a cleat or partition, extending entirely across the trough, reaches from the bottom almost to the top, and another similar partition at the upper end of the compartment reaches from the top almost to the bottom of the trough. The water is consequently forced to flow under the upper partition and over the lower partition, and in order to do this it must necessarily ascend through the trays of eggs.

Two results are secured by this method:

(1) The trays may be made several inches deep and may be filled at least half full of eggs.

(2) A good but gentle circulation is continually maintained through the eggs.



BAIRD STATION. OUTLET OF WILEY CREEK DITCH ON COLCHOOLOOLOO HILL, SHOWING WATER CONNECTIONS WITH HATCHING HOUSE.

This ditch furnishes the water supply for hatching house during the winter.

An unusual advantage is gained in consequence, viz, ten times as many eggs can be hatched in the same space and with the same supply of water as by the old methods.

My report for 1874–75 speaks as follows of these hatching-troughs:

Too much can not be said in praise of these hatching-trays. With them it is only necessary, in picking out the white eggs, to raise the tray a little ways out of the water and gently immerse it again. The upward pressure of the water throws the dead eggs to the surface, where they can be picked out without even the touch of a feather. With these trays the hands are never wet, the trays are never changed from their places, the eggs never flow over the top, and the feather becomes unnecessary. In addition to these advantages, all sediment accumulating about the eggs can be easily run off by gently moving the tray up and down a few times in the water.—(United States Fish Commissioner's Report, 1874–75, page 447.)

In 1876, after a year's experience with these hatching-troughs, my report alludes to them again as follows:

The hatching apparatus is the same used last year, namely, the Williamson troughs, with the deep wire baskets described in last year's report. I ought to add here that the wire baskets gave the same satisfaction that they did the year before. *They are unquestionably the best thing known for maturing salmon eggs on a large scale.* Of the utmost simplicity in construction, they are more easily handled and will hatch more eggs with *less cost, less loss, less room,* and *less labor* than any other hatching apparatus in use.—(United States Fish Commissioner's Report, 1875–76, page 939.)

For some unaccountable reason this method of hatching the eggs of the *Salmonidæ*, which is now almost universally in use in the hatcheries of European countries, is seldom employed in this country, except on the Pacific Coast. The writer confidently recommends it, however, as the best method in existence. At the hatching-house at Baird,[1] the trays are 22 inches long, 12 inches wide, and 6 inches deep, the trough compartments in which they are placed being just enough longer to enable the trays to be raised and lowered, and to be also tilted slightly, without too much friction against the partitions and sides of the trough.

The troughs themselves are all 16 feet long and have a fall of 1½ inches to each. They are covered with canvas covers made sunlight proof by having been saturated with asphaltum varnish. I need hardly add that the trays and also the interior of the troughs are thickly coated with asphaltum.

The water supply for the first hatching apparatus (1872) was obtained from a small brook. After that, until 1890, it was obtained directly from McCloud River by a current wheel placed in the river near the hatching-house. The last automatic current wheel used was about 100 feet in circumference.

For the last few years the wheel has been made much smaller and has been used to produce power to work a centrifugal pump that pumps the water from the river up into the hatching-house. The writer, however, strongly recommends, on account of its perfect simplicity, the large wheel formerly used, that lifted the water automatically in buckets to the necessary height. In the wheel and pump combination there are numerous belts and pulleys and minor wheels and other machinery that are continually getting out of order, and consequently causing expense of time and money, besides creating various frictions which require continual watching. But with the automatic wheel there are no belts, no pulleys, no subsidiary wheels, nothing to wear out or get out of order, nothing to watch, and only one thing to cause friction, viz, the

[1] At Sisson station and Battle Creek station of the California Fish Commission the troughs are 16 or 18 inches wide, which I consider a better width than 12 inches, and would cordially recommend it.

revolving axle of the wheel, the bearings of which do not need to be oiled oftener than once a day.

For the first fifteen years of operations at this station after 1873 the current wheel was relied upon exclusively to furnish the water supply for the hatching-house. A steam engine and miner's pump were then introduced as a reserve agency to furnish water in the event of any accident to the wheel, and in 1895 a ditch was built to take water from Wiley Creek to the hatching-house by force of gravitation. The ditch is nearly 1¼ miles long, and furnishes an excellent water supply during the rainy season, when the river is too high to manipulate the wheel.

At the Clackamas station, in Oregon, the water supply was first obtained from the Clackamas River by a current wheel operating a Chinese pump, which lifted the water 27 feet into a flume running to the hatching-house. Subsequently water was taken from a point on Clear Creek, about a quarter of a mile distant, but owing to the nature of the bed of the creek no dam could be made to stay there, and now the water supply is pumped up from the Clackamas by a steam pump.

At Fort Gaston station, in Humboldt County, Cal., as also at the branch station at Redwood near by, the water supply for the hatching-house is taken from spring-fed streams in the neighboring hills.

To return again to Baird station, I will say that after the salmon are measured out and placed in hatching-trays very little is done to them except a slight picking over and rinsing off of sediment until the "delicate stage" is reached, which is just as the spinal column is forming. Then they are left alone until the distinct line of the backbone, becoming visible in the embryo, indicates that the delicate stage is passed. Then the white eggs are carefully picked out, and after a little, when the appearance of the choroid pigment (eye-spots) shows that the eggs can stand comparatively rough usage, they are "dippered," or the water otherwise actively agitated in order to kill off all the empty eggs. When these are removed the eggs are ready to be packed for shipment or to be hatched, as the case may be.

If the eggs are to be hatched, wire trays are used with every other strand lengthwise of the bottom of the tray removed, which enables the newly-hatched fish, as fast as they emerge from the eggs, to slip down into the trough below, where they can be kept, if desired, or whence they can be easily removed, if necessary.

PACKING THE EGGS.

The packing of eggs for shipment from this station over long distances has always been the same. The packing boxes are made of half-inch pine, 2 feet square and 1 foot deep. At the bottom of the box is placed a thick layer of moss, then comes one thickness of mosquito bar, then a layer of eggs, then mosquito bar again, then other successive layers of moss, netting, eggs, netting, and so on to the middle of the box. Here a firm wooden partition is fastened in, and the packing renewed above the partition in the same manner as below. The cover is then screwed on the top and another box packed. When two boxes are ready, they are placed in wooden crates, made large enough to allow a space of 3 inches on all sides of the boxes. This space is filled with hay to protect the eggs against changes of temperature. The cover being put on the crate and the marking done, the eggs are ready to ship.

I should have added that in the middle of the crate an open space is left about 4 inches in depth between the two boxes of eggs for ice. As soon as the crates arrive

at the railway station, this space is filled with ice and the top of the crate is also covered with ice.

The following letters show how the eggs, packed as above described, survived their overland journey in 1878:

MOUNT CARROLL, ILL., *October 16, 1878.*

DEAR SIR: The two crates of California salmon eggs, of which you notified me from California, reached me on the 14th instant. They are *in fine condition, only about 3 per cent* being found faulty.

Very truly, yours,

SAMUEL PRESTON.

LIVINGSTON STONE, Esq.

GLOUCESTER, MASS., *October 18, 1878.*

MY DEAR SIR: My man writes me of the safe arrival of the salmon eggs *in good condition.* Out of the lot of 250,000 he picked out 6,000 bad eggs, 2.4 per cent.

Yours, very respectfully,

FRANK N. CLARK.

LIVINGSTON STONE.

ST. PAUL, MINN., *October 28, 1878.*

DEAR SIR: The California salmon eggs from the McCloud River came to us on the evening of the 14th, and I am glad to say that they open up in better order than any we have ever received before. The packing and carriage were a complete success, and up to this time *the loss has not been over 5 per cent.*

Very respectfully,

R. O. SWEENY.

Hon. S. F. BAIRD, *United States Fish Commissioner.*

TRENTON, N. J., *October 14, 1878.*

DEAR SIR: In accordance with your request of September 23, you are informed that the shipment of salmon eggs for the State of New Jersey, and others (total, 475,000), was received in due time, and that the condition of the eggs on arrival *was most excellent.*

Very respectfully,

E. J. ANDERSON,
Commissioner of Fisheries of New Jersey.

LIVINGSTON STONE, Esq.

ELGIN, ILL., *October 12, 1878.*

DEAR SIR: The California salmon eggs came *in excellent shape.*

W. A. PRATT.

LIVINGSTON STONE.

COUNCIL BLUFFS, IOWA, *October 17, 1878.*

DEAR SIR: The 50,000 California salmon eggs shipped me per express were duly received on the 14th instant, and in unpacking the same I find them *in excellent condition.*

Yours, respectfully,

WM. A. MYNSTER.

LIVINGSTON STONE.

All the salmon eggs forwarded from this station were sent by express (the express messengers being instructed to keep the crates plentifully re-iced in transit), until 1876, when an ice car was used for transporting the eggs from Redding to Chicago, whence they were distributed to their eastern destinations. The ice car, which to start with was only a common box-freight car, was sent by the railroad company to Redding, the nearest railway point from Baird, with a ton or so of ice. The crates of salmon eggs in the meantime were forwarded by wagon from Baird. They were then packed into the car and the car sent down to Sacramento and filled up with ice; on the same day it left for Chicago on the regular passenger train of the Central Pacific.

The method of packing with moss, as above described, has always been employed at this station for shipping eggs over long distances, but for short distances the Annin packing box is used. This box is too well known to need description. I will only say that in my experience it has always answered its purpose admirably. We have frequently even found a few eggs alive in the return boxes, that had been overlooked in unpacking and which had remained in the box two or three weeks.

The following excellent tabulated statement,[1] prepared by Mr. Smiley, may not be out of place here.

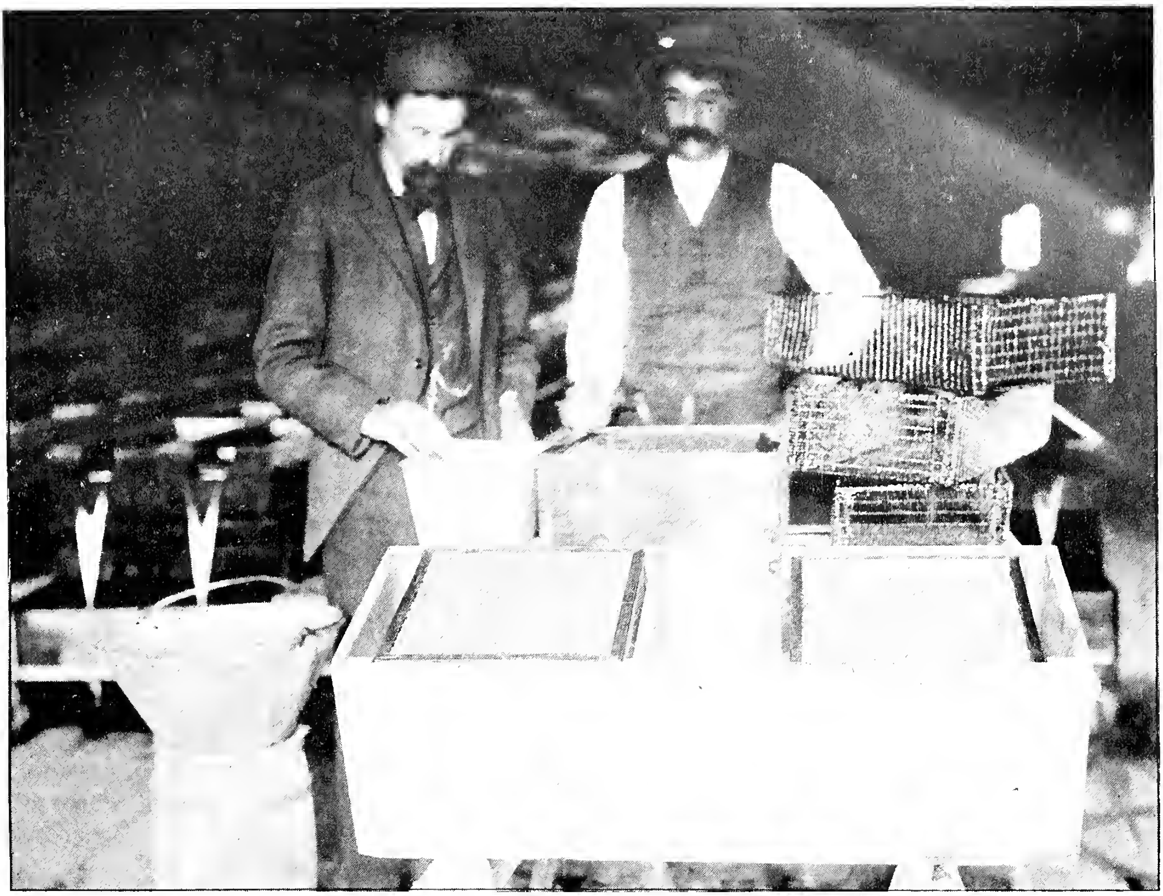
Table showing the success in transporting and hatching 31,193,000 salmon eggs.

State to which consigned.	Number of eggs sent from McCloud River.	Received at State hatcheries.	Loss in hatching and transporting to waters.		Young actually introduced.	
			Number lost.	Per cent.	Number.	Per cent.
Colorado	565, 000	565, 000	92, 100	16	472, 900	84
Connecticut	1, 410, 000	1, 390, 000	191, 714	13	1, 198, 286	87
Illinois	1, 030, 000	930, 000	362, 300	39	567, 700	61
Iowa	1, 050, 000	1, 100, 000	86, 800	8	1, 013, 200	92
Kansas	400, 000	400, 000	20, 600	5	380, 000	95
Kentucky	355, 000	350, 000	232, 275	66	117, 725	34
Maine	215, 000	165, 000	77, 300	47	87. 700	53
Maryland	4, 645, 000	4, 440, 000	1, 175, 601	29	3, 264, 399	71
Massachusetts	740, 000	728, 000	259, 000	36	469, 000	64
Michigan	3, 908, 000	3, 868, 000	618, 979	16	3, 249, 000	84
Minnesota	2, 825. 000	2, 627, 500	1, 751, 750	64	875, 750	36
Missouri	410, 000	400, 000	64, 000	16	336, 000	84
Nebraska	710, 000	600, 000	110, 000	18	490, 000	82
Nevada	250, 000	250, 000	50, 000	20	200, 000	80
New Hampshire	555, 000	467, 000	37, 960	8	429, 540	92
New Jersey	2, 480, 000	2, 430, 000	330, 371	14	2, 099, 629	84
New York	1, 135, 000	980, 000	144, 790	15	835, 210	85
North Carolina	1, 100, 000	1, 117, 500	369, 500	33	748, 000	67
Ohio	500, 000	500, 000	127, 500	26	372, 500	74
Pennsylvania	2, 440, 000	2, 385, 000	483, 500	20	1, 901, 500	80
Rhode Island	340, 000	220, 000	40, 000	18	180, 000	82
South Carolina	250, 000	333, 000	121, 000	36	212, 000	64
Tennessee	100, 000	(a)	(a)	(a)	(a)	(a)
Utah	600, 000	625, 000	114, 500	18	510, 500	82
Virginia	1, 270, 000	1, 285, 000	358, 500	28	926, 500	72
West Virginia	810, 000	785, 000	47, 625	6	737, 375	94
Wisconsin	1, 100, 000	1, 130, 000	300, 400	27	829, 000	73
Total	31, 193, 000	30, 071, 000	7, 567, 465	25	22, 504, 035	75

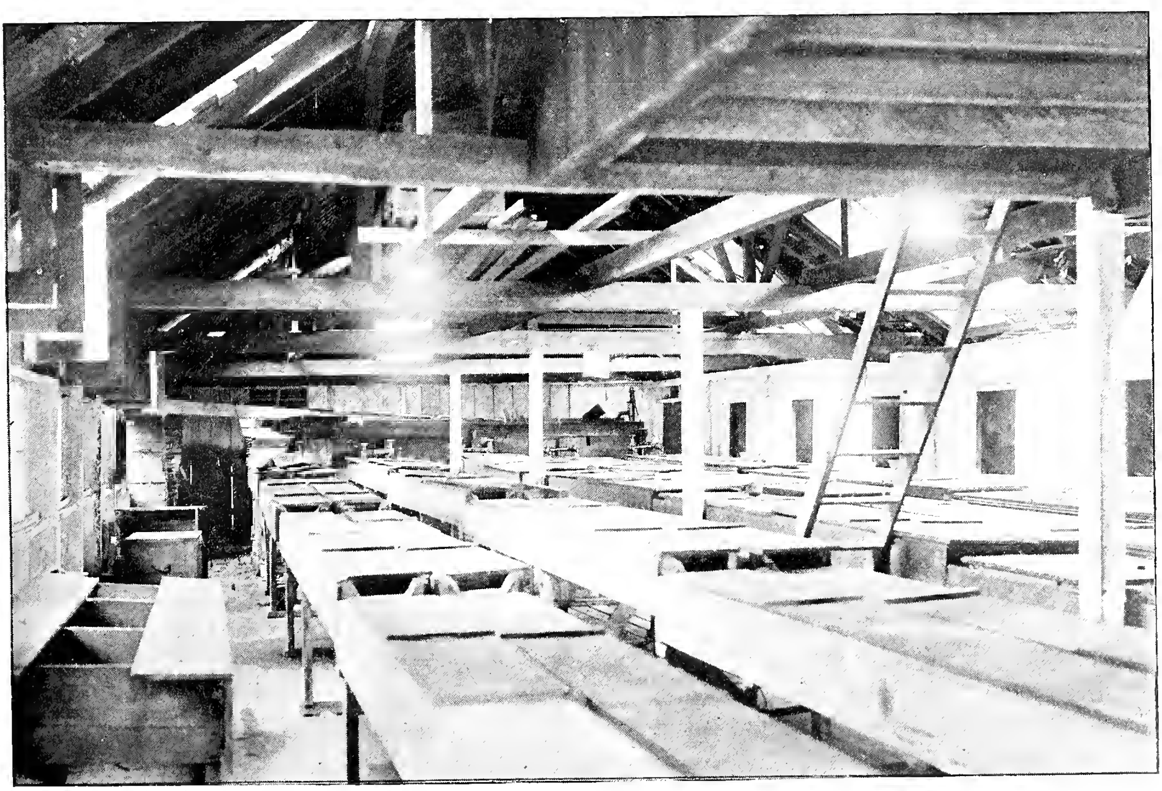
a No report received.

It will be seen by the above table that the gratifying average of 75 per cent of all the 30,000,000 eggs distributed from Baird station in the ten years from 1872 to 1881, inclusive, were actually hatched out, and the fish deposited in the waters of the Atlantic States.

[1] United States Fish Commissioner's Report, 1881, page 837.



PACKING SALMON EGGS AT CLACKAMAS HATCHERY.



INTERIOR OF HATCHING HOUSE, BAIRD STATION.

I will, in conclusion, quote some remarks on the results of salmon breeding in California from the report of the California State Fish Commission for 1893–94:

Our salmon fishery is of the greatest importance to us, as it furnishes a larger supply by 800,000 pounds than any other food-fish, the catch being 4,848,816 pounds in 1892. Hatching operations were inaugurated in 1873. In 1875 the take (of salmon in the Sacramento and San Joaquin) was 5,098,781 pounds; in 1878, 6,520,768 pounds; and in 1880, 10,837,400 pounds.

In 1884, it became necessary to close the spawning station at Baird, as the salmon were prevented from ascending Sacramento River to that point by blasting operations above Redding, occasioned by the building of the railroad. Consequently, the planting ceased and this station was not operated until 1888. The result was that the catch decreased until the effects of the resumption of the artificial hatching again began to show in 1892. Since 1892 the increase has been very marked, and the results of the planting of fry each year are again demonstrated.

Since 1892 the salmon pack at the canneries has steadily increased, while at the same time there has been a much larger demand for salmon in the markets of the State.

The following table shows the decrease in the pack to 1892 and the subsequent increase, which we hope to see continued:

Year.	Pounds.	Cases.
1888	4,039,200	61,200
1890	1,618,471	25,065
1891	672,121	10,353
1892	170,425	2,281
1893	1,496.927	23,336
1894	1,940,009	28,463

Through the kindness of Mr. J. P. Babcock, chief deputy of the California Fish Commission, I have just been furnished with the following interesting statistics, illustrating the increase of salmon in the Sacramento, from 1893 to 1895. October of 1895 being a close month, the total number of pounds given for that year is, of course, less than it would otherwise have been. If, to supply the deficiency, we add the average of October, 1893 and 1894, to the total of 1895, which would then put the latter year on a basis of fair comparison with the two previous years, it makes the total of 1895 3,040,000 pounds, or a gain of nearly 25 per cent over the year 1893.

Table showing number of pounds of fresh quinnat salmon handled in the San Francisco markets in 1893, 1894, and 1895.

Months.	1893.	1894.	1895.
	Pounds.	*Pounds.*	*Pounds.*
January	137,460	128,556	161,641
February	93,263	103,801	146,250
March	139,401	163,131	155,791
April	374,478	211,552	365,387
May	325,170	242,126	401,787
June	70,216	138,675	161,989
July	149,217	117,516	115,592
August	575,609	576,991	447,094
September	(*a*)	(*a*)	(*a*)
October	249,753	403,340	(*a*)
November	183,789	276,768	431,453
December	155,090	192,153	326,474
Total	2,453,446	2.554,609	2,713,458

a Closed season.

NOTES ON THE NATURAL HISTORY OF THE QUINNAT SALMON.

The quinnat salmon (*Oncorhynchus tschawytscha*) has almost as many local names as the North American panther (*Felis concolor*). I think its first popular name was the "Columbia River salmon," and its first scientific name, in general use, was *Salmo quinnat*. Time and closer acquaintance with the fish has robbed it of both these names. What its most accepted popular name is at present it would be hard to say, but its generally received scientific name is now *Oncorhynchus tschawytscha*, this Russian cognomen having been found to supersede by many years the *Salmo quinnat* of Gairdner & Suckley. The origin of the term "quinnat" is involved in obscurity. Several explanations have been offered for it, but the most probable seems to be that the name was derived from the Indian name (*Quinnault*) of a tributary of the Columbia, where the finest salmon of the river were supposed to be caught. Everyone knows the tendency of every article to take the name of the place where it is found at its best; accordingly, the best Columbia River salmon being found in Quinnault River, all the Columbia River salmon came to be called *Quinnault*, or *quinnat*, salmon, the latter word being the former with the *l* dropped.

Other popular names of this salmon are "spring" salmon and "chinook" salmon, by which names it is commonly known on the Columbia River. On the Sacramento River it is known simply as "salmon," there being no other kind of salmon to amount to anything in the Sacramento. Its name in the Chinook dialect is "tyee" salmon (king salmon), by which latter name it is known farther north and on the Yukon. The local Indian name for salmon on the McCloud is "noolh."

The following is Dr. Suckley's description of the quinnat salmon, taken from the United States Fish Commissioner's Report, 1872–73, page 105:

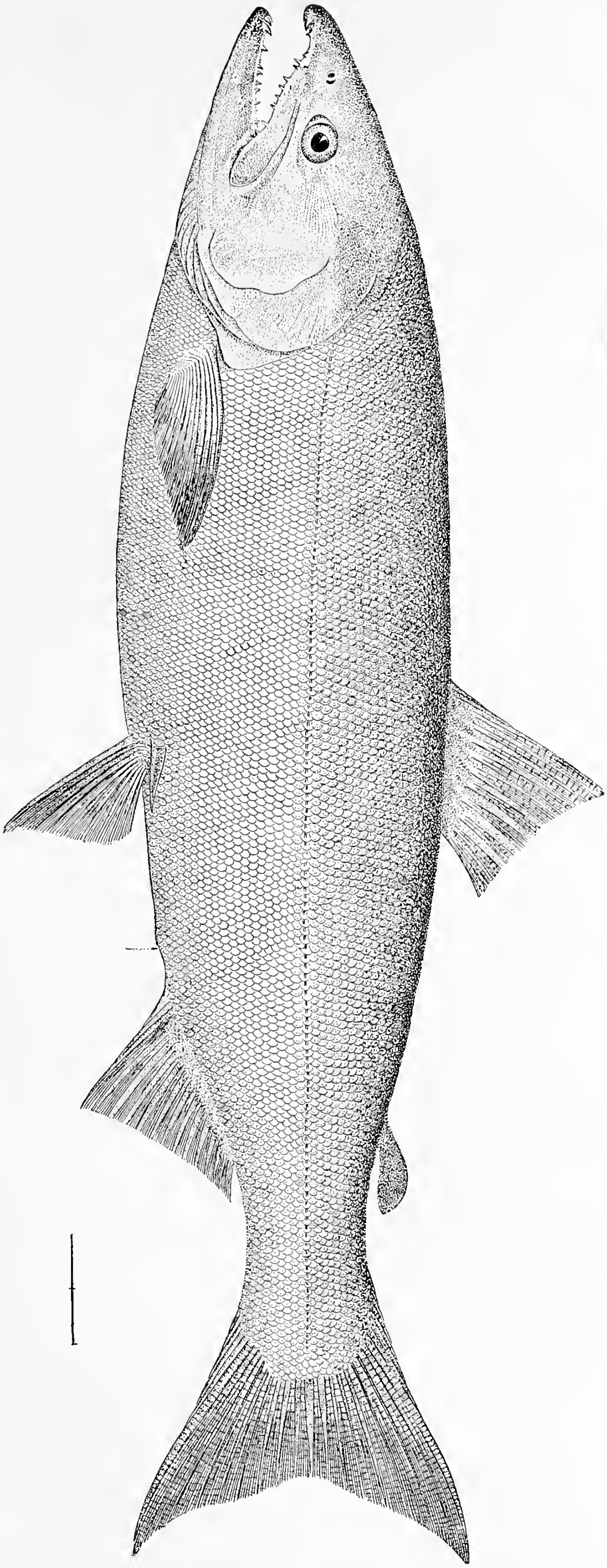
Salmo quinnat Richardson.

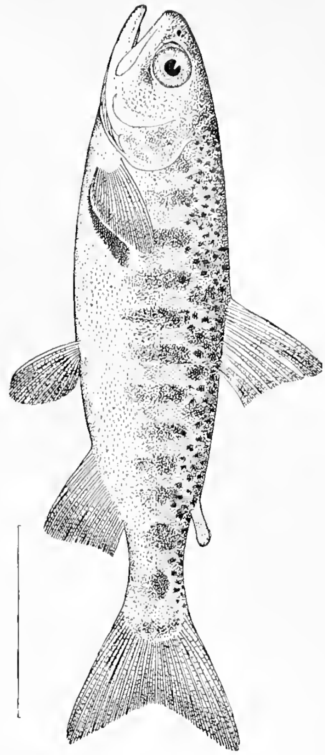
Sp. Ch.—*Adult.*—Head pointed and large, forming about a fourth of the length from the snout to the end of the scales on the caudal. Dorsal outline regularly arched. Caudal deeply cut out (in the dried specimen forked), snout cartilaginous, as in *S. salar*. Chin pointed, a triangular bare projection extending beyond the teeth.

General tint of the back, bluish gray, changing after a few hours' removal from water into mountain green; sides ash-gray, with silvery luster; belly white; back above the lateral line studded with irregular rhomboidal or star-like spots, some of them oscillated; dorsal fin and gill cover slightly reddish; tips of the anal and pectorals blackish gray; the dorsal and caudal thickly studded with round and rhomboidal spots; back of the head sparingly marked with the same. The whole body below the lateral line, with the under fins, destitute of spots. (Gairdner in Rich., F. B. A., Fishes, 220.) Scales large. Branchiostegal rays varying from 16 to 20.

The quinnat salmon or chinook salmon is very widely distributed on the Pacific coast. As far south as the mild climate of Santa Cruz in California it is caught, and as far north as the frozen waters of the Arctic it is found in abundance; and no Pacific Coast stream from the Sacramento to the Yukon is found without it.

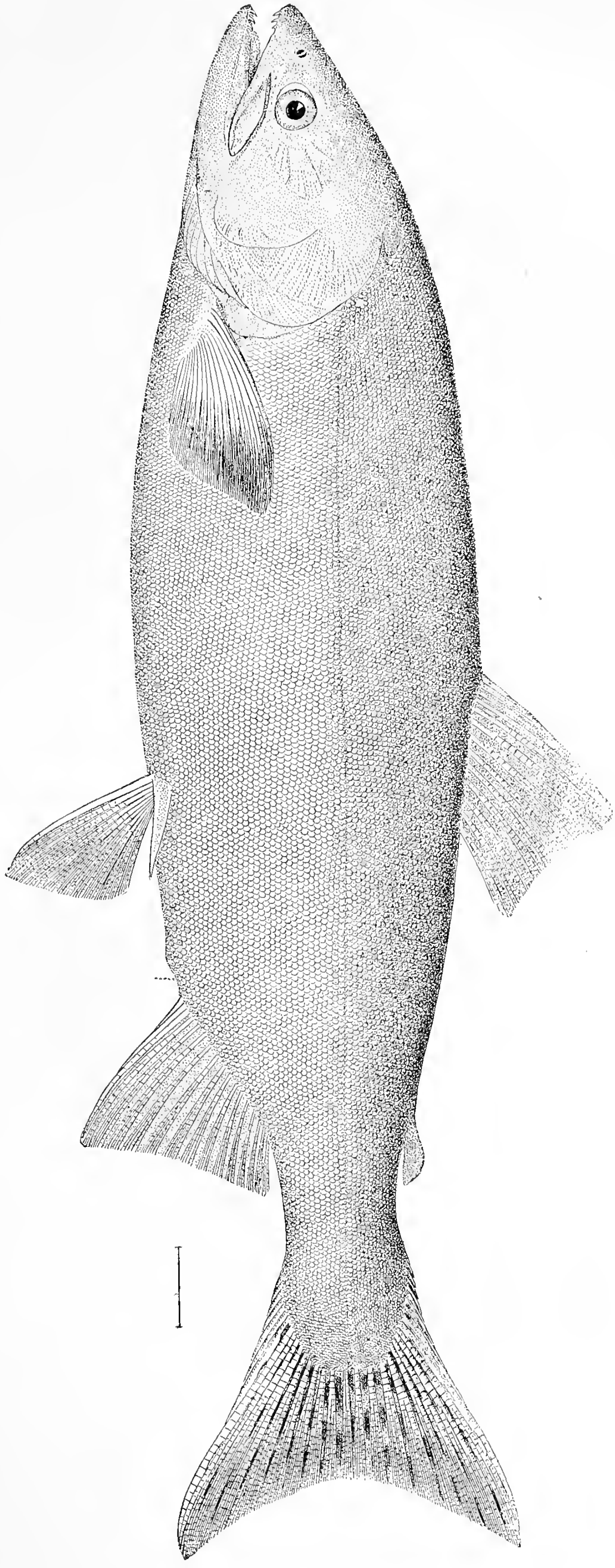
The quinnat salmon, when freshly caught and in its prime, is a very handsome, plump-looking, silvery fish, more or less covered with fine black spots; and though it shows its claim to royal lineage in its whole appearance, it does not possess the graceful hues and curves of its Atlantic cousin, *Salmo salar*, which, however, it very much resembles. In flavor, also, its flesh, though good when cooked, suffers from





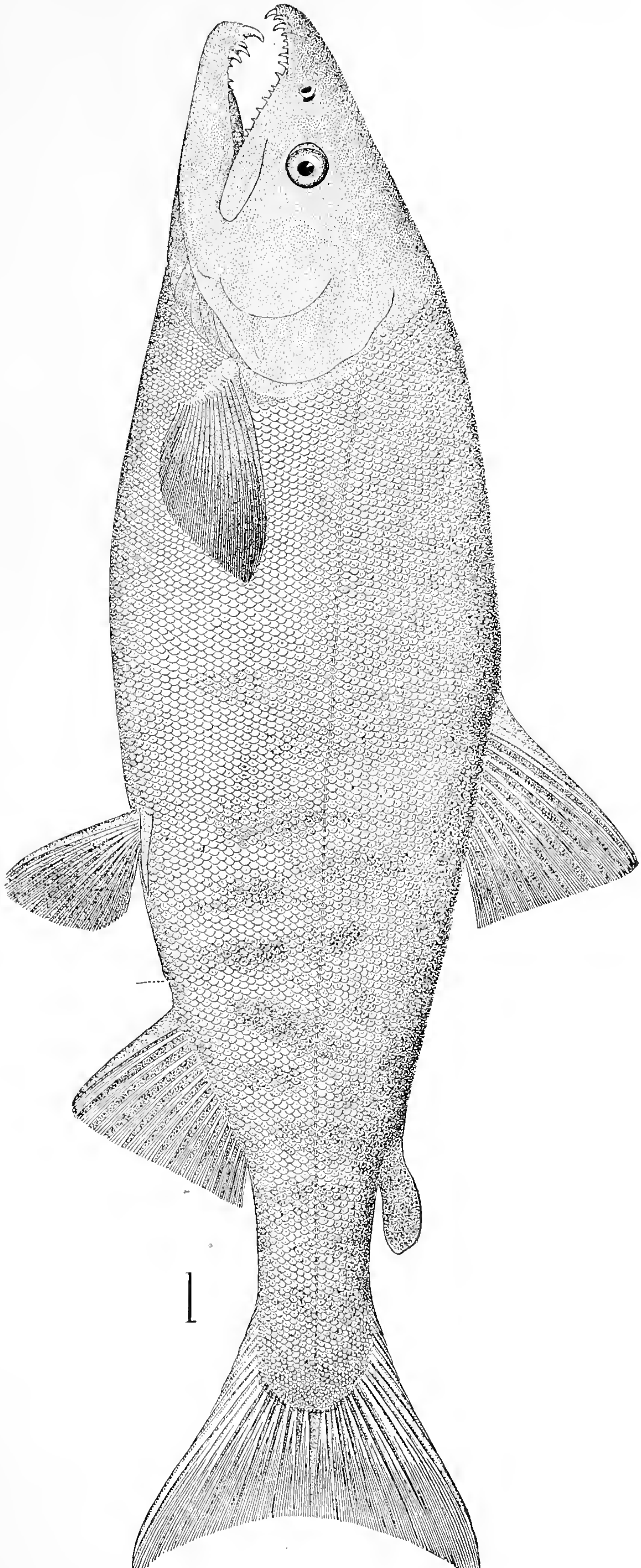
ONCORHYNCHUS TSCHAWYTSCHA (Walbaum). *Quinnat Salmon; Chinook Salmon; King Salmon; Sacramento Salmon.*

The upper figure is drawn from a young example, 4 inches long, taken in Alturas Lake, Idaho, September 9, 1895.



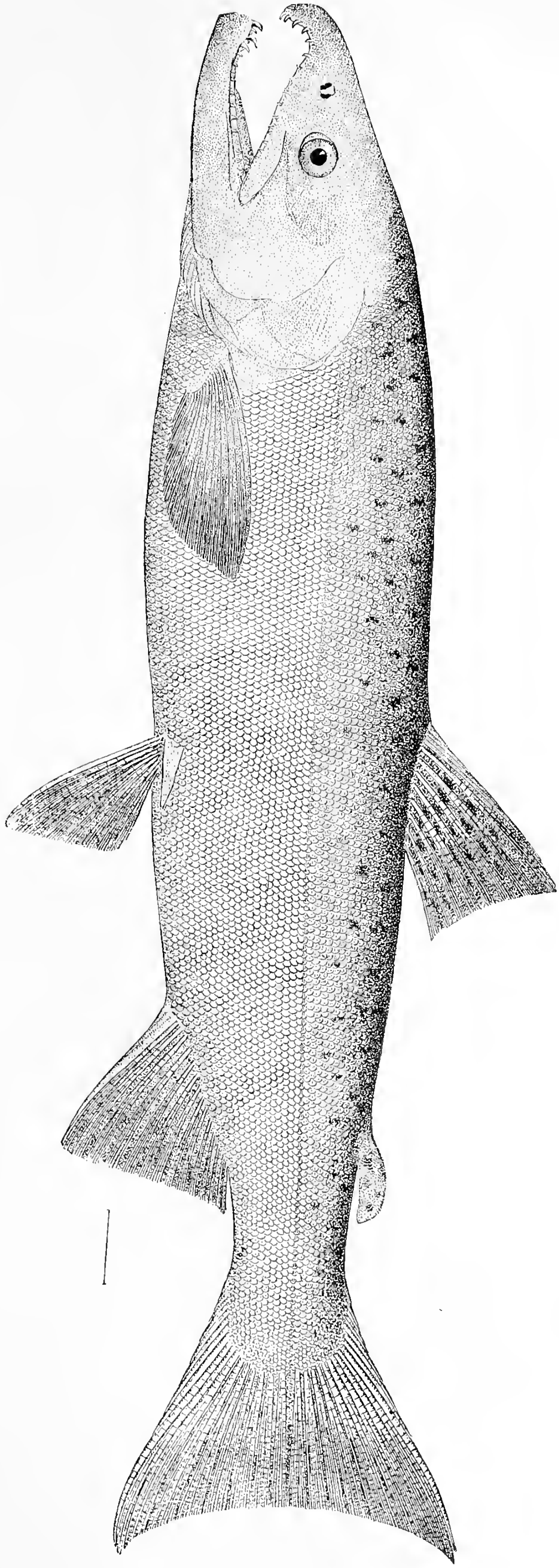
ONCORHYNCHUS GORBUSCHA (Walbaum). *Humpback Salmon.*
Drawn from a specimen collected in Cook's Inlet, Alaska.

PLATE 81.

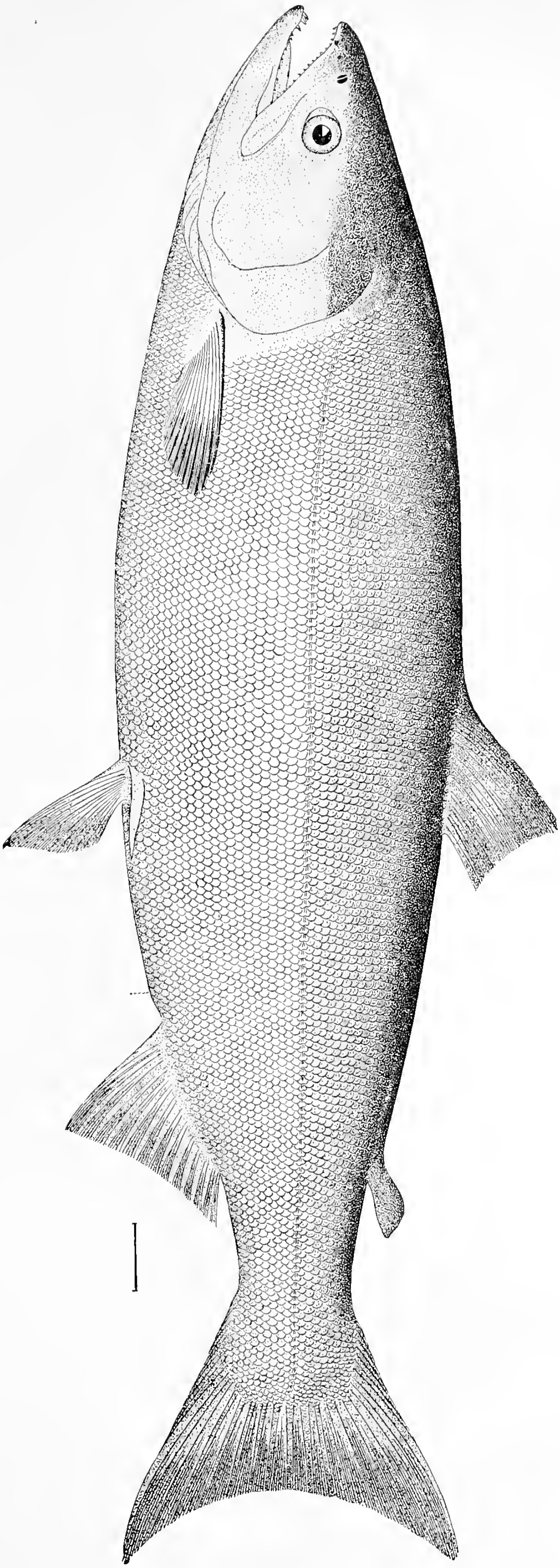


ONCORHYNCHUS KETA (Walbaum). *Dog Salmon.*

Drawn from a specimen collected at Fort Alexander, Cook's Inlet, Alaska.

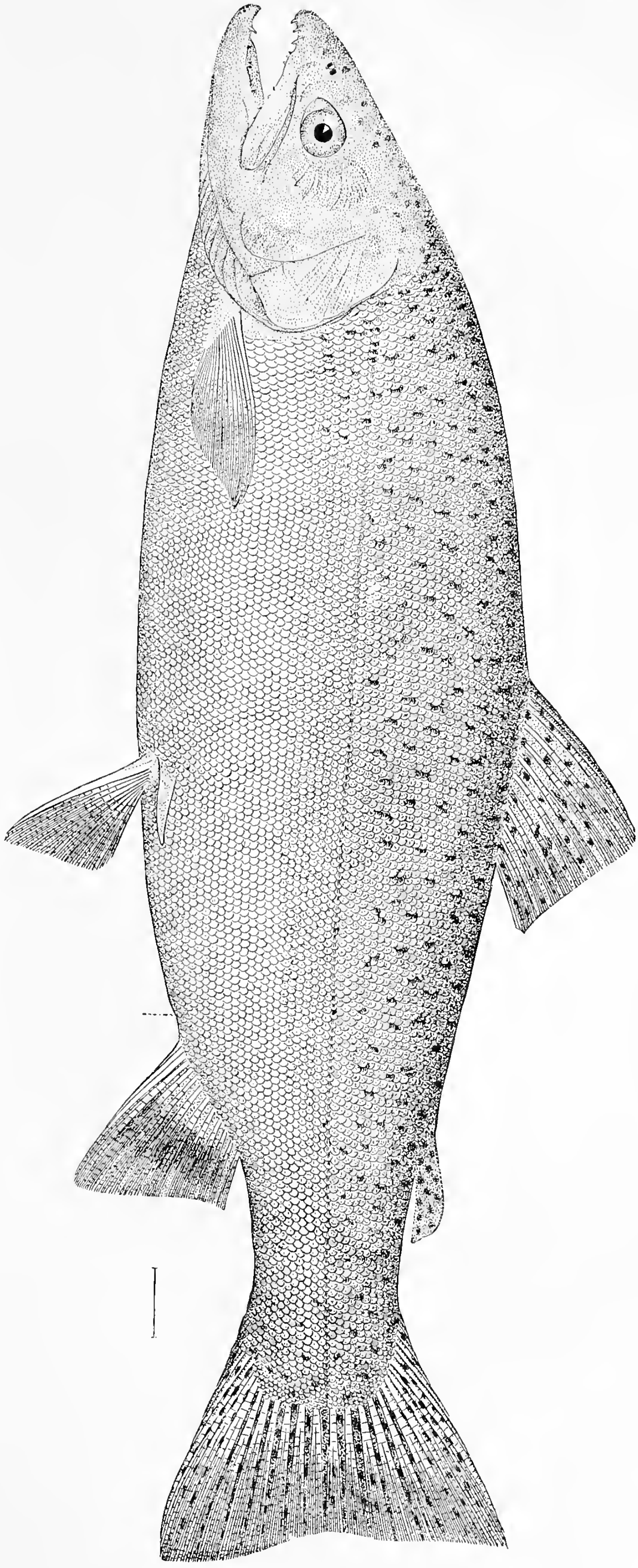


ONCORHYNCHUS KISUTCH (Walbaum). *Silver Salmon.*
Drawn from a specimen collected at Unalaska.



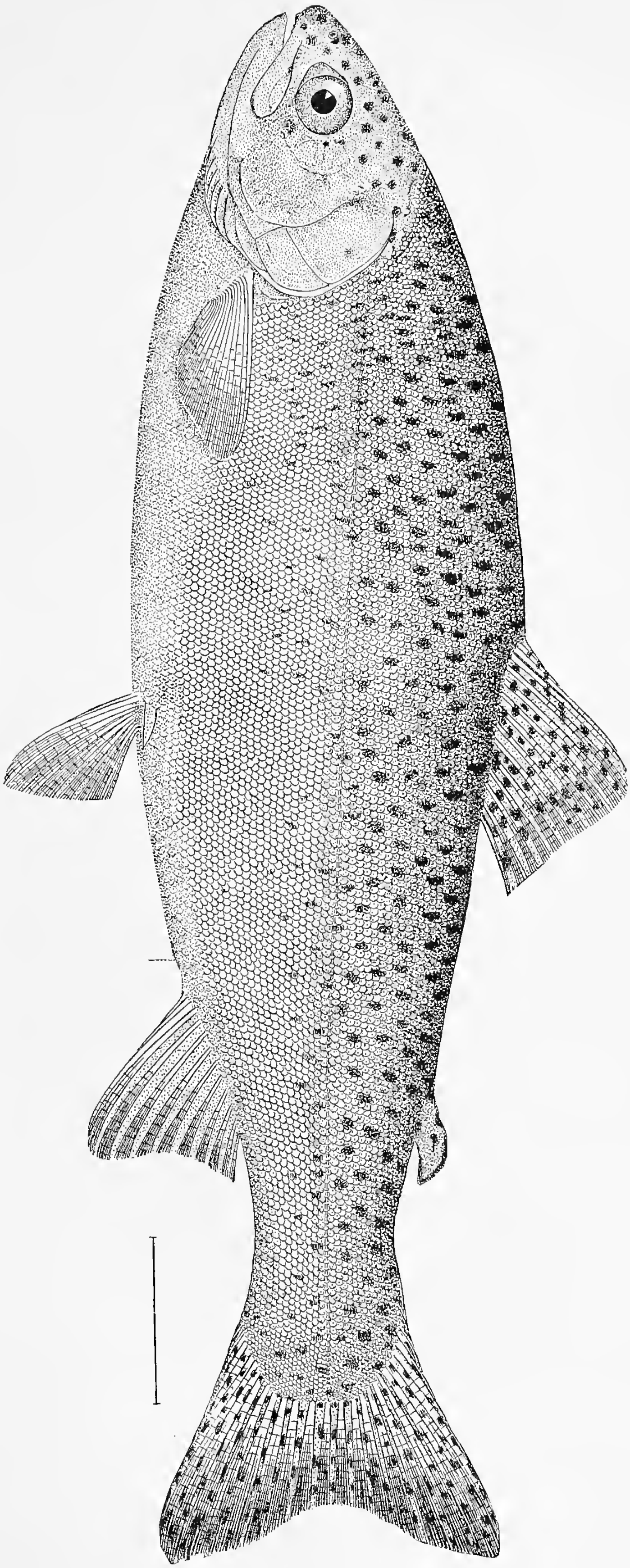
ONCORHYNCHUS NERKA (Walbaum). *Blueback Salmon; Redfish; Sawkeye Salmon; Fraser River Salmon.*

Drawn from a fresh-run male taken in the Columbia River.



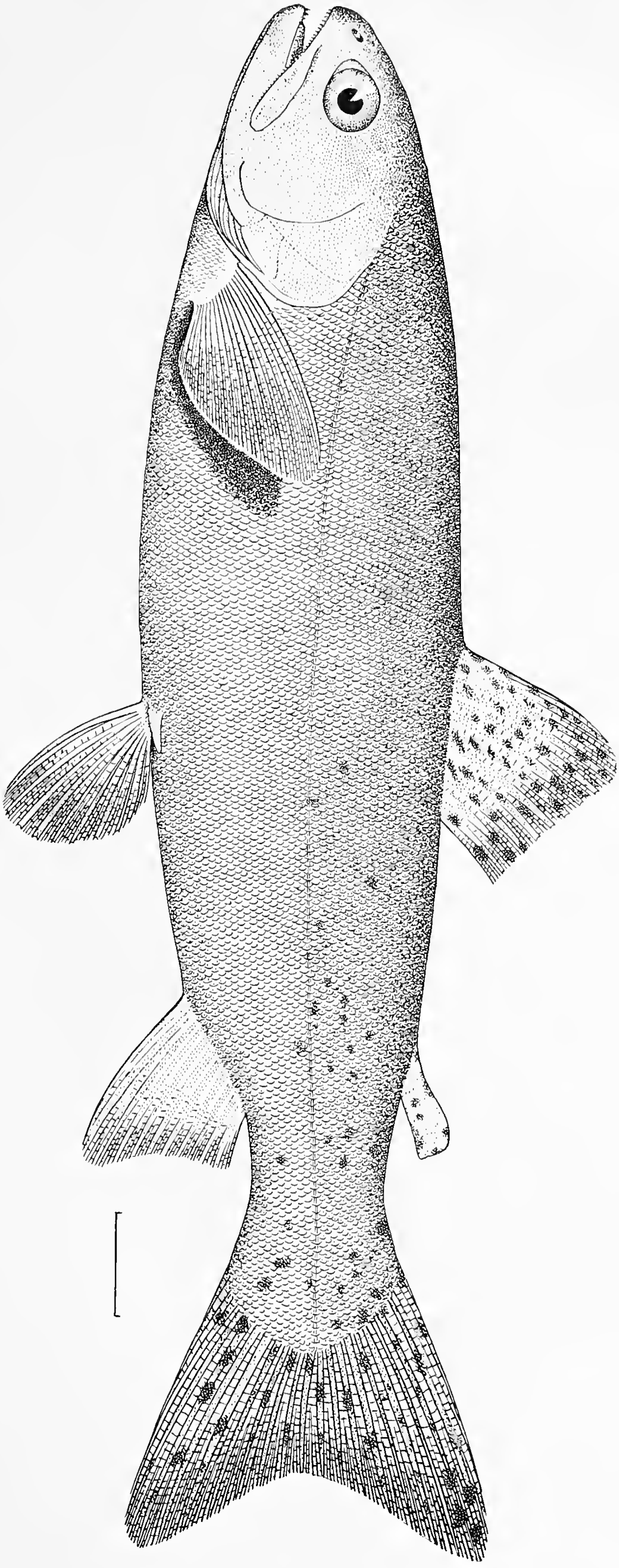
SALMO GAIRDNERI Richardson. *Steelhead; Steelhead Trout; Salmon Trout.*

Drawn from a specimen collected in the Columbia River.

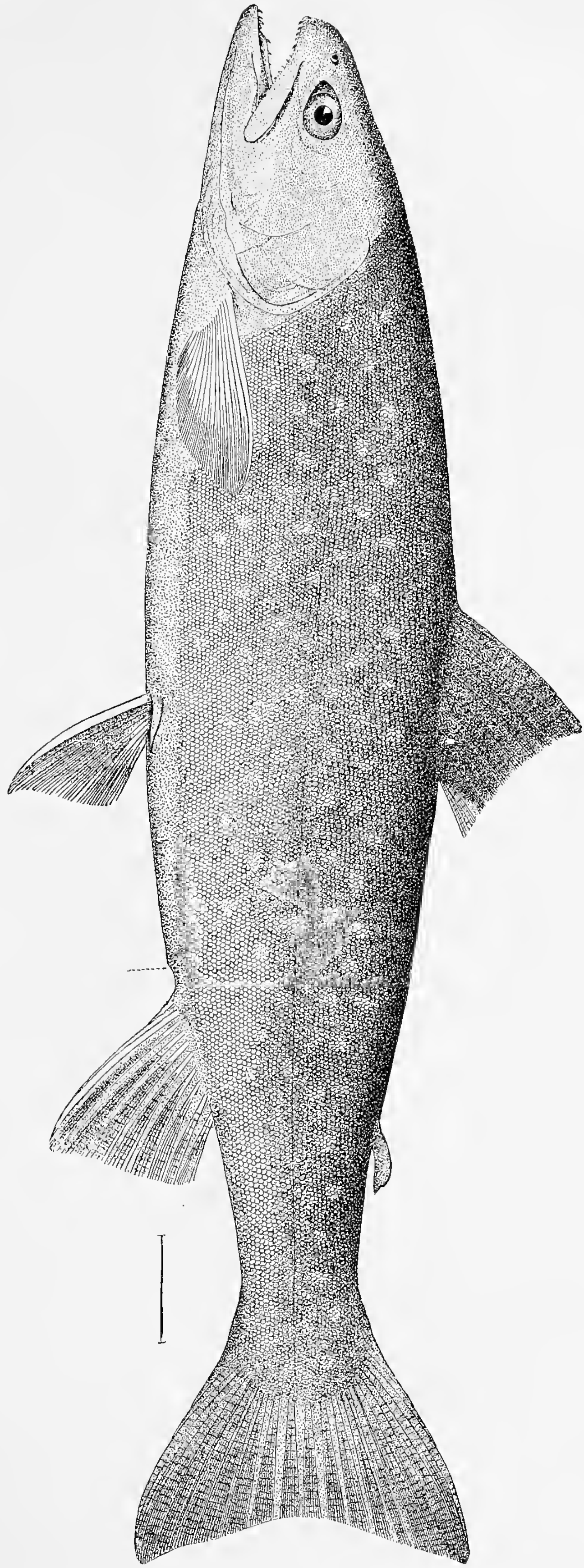


SALMO IRIDEUS Gibbons. *Rainbow Trout*

Drawn from a specimen collected in McCloud River, California.



SALMO IRIDEUS STONEI (Jordan). *No-Shee Trout; Stone's Trout.*



SALVELINUS MALMA (Walbaum.) *Dolly Varden Trout; Bull Trout; Western Charr.*
Drawn from a specimen collected at Port Chatham, Cook's Inlet, Alaska.

comparison with the inimitable salmon of the Atlantic; and still another charge is brought up against it, viz, the old but true indictment that it does not rise to the fly. Nevertheless, with all these handicaps, it holds a high place among the fishes of the seas for beauty, gameness, food value, and commercial value, in the two latter points of which, on account of its almost incredibly vast numbers, it completely eclipses the Atlantic salmon. In all the rivers in which it is found it occurs in great multitudes, and in the upper waters of these streams the old story, so hard for the skeptical to accept, is true, that the salmon are found at certain seasons so thick that one could cross the stream dry-shod on their backs if he could keep his balance.

There is no month of the year when there are not salmon in the Sacramento, but their first appearance in abundance on the Pacific Coast of the United States is at Santa Cruz Bay, in January. Here they are caught in very considerable numbers by hook and line, either by trolling or from a boat at anchor, as mackerel or perch are caught. Through January and February they are increasing in the main Sacramento, but do not become abundant till March, when they swarm up the river and are caught in great quantities in nets, as also in April. In May, June, and July they fall off, but reappear in great numbers in August. They fall off a little in the latter part of September, and continue to grow scarcer in the main river till the end of the year.

The number of fresh salmon shipped from Rio Vista to San Francisco in the year 1872 was as follows:

January	792	August	1,496
February	1,581	September	2,335
March	1,945	October	583
April	3,354	November	441
May	4,408	December	390
June	1,201		
July	1,145	Total	19,671

Their movements in the Columbia are quite different. Here they make their first appearance in February, though in very small numbers. The main body arrives in May, June, and especially in July, when the run is enormous. The May salmon are largest. Perhaps the most correct view to take of the running of the salmon is to consider all the salmon as included in one run, beginning in February, increasing in May and June, and culminating in July; though they might also be legitimately divided into three runs, the first or meager run coming in February, March, and April, the second or full run in May and June, and the third or maximum run in July. After July they diminish rapidly, and soon almost entirely disappear from the main river.

The writer has always been told by the professional fishermen on the Sacramento and Columbia that the salmon come down the ocean from the north to the mouths of the rivers, but their regular appearance on the coast of southern California early in January, their subsequent appearance in the Sacramento in February, and their still later appearance in the Columbia in March seem to indicate quite conclusively that the salmon came up the coast to these rivers from points farther south, to which they have migrated for a sojourn during a portion at least of the winter months.

It is probably true of most anadromous fish which leave the ocean to go up fresh-water streams to spawn, that they eat little or nothing after they get above tide water. At all events, as soon as the quinnat "salmon, coming from the sea, strike fresh water their appetites begin to weaken, their throats begin to narrow, and their stomachs begin to shrink. This does not at first, however, entirely prevent them from feeding, but it changes them enough to enable them to overcome the temptation to return to

their well-stocked feeding-grounds in the salt ocean; and the longer they remain in fresh water the greater the changes become, and the temptation to turn back for food correspondingly less. There is probably no one specified time when an abrupt change comes which deprives them in an instant of their ability and desire to feed, but in the writer's opinion the transformation comes on gradually, increasing constantly day by day from the time they leave tide water till, at the near approach of the spawning season, their throats and stomachs become entirely incapacitated for receiving food, and the desire and ability to feed leave them entirely; but, notwithstanding their scanty supply at first and their entire abstinence afterwards, the great reserve of superfluous flesh and blood, which they bring with them in their own bodies from the bountiful ocean, enables them with little or no food in their stomachs to keep their vital organs in vigorous activity until their momentous mission up the fresh-water streams is accomplished."[1] In the ocean their staple food consists of smaller fish.

It is a singular fact regarding the quinnat salmon that those, at least, that spawn a long distance from the ocean never return to it again alive. *They all die on their spawning-grounds.* This fact, I am aware, has been disputed many times, and is by no means universally accepted now, but its truth has been proved so repeatedly and conclusively that it is no longer open to question. My report for 1872–73 says on this point:

> In March, when the salmon first arrive in the McCloud, they are in fine condition. They are now bright and silvery, with shining scales. They are fat and excellent for the table, but not very large. The spawn in the females is very small. Their flesh is of a deep red color. The males and females are almost indistinguishable at this time. This state of things remains till August, except that the salmon gradually deteriorate in quality and the eggs increase in size. The first marked change in the fish takes place a little before the middle of August. The salmon then become very black. The males grow deep and thin, and the dog-teeth begin to show themselves and to increase rapidly in size. The females are now big with spawn, and the sexes are easily distinguishable. From this time they rapidly deteriorate. Their flesh shades off to a light, dirty pink. They become foul and diseased, and very much emaciated. Their scales are wholly absorbed in the skin, which is of a dark olive hue, or black. Blotches of fungus appear on their heads and bodies, and in various places are long white patches where the skin is partly worn off. Their fins and tails become badly mutilated, and in a short time they die exhausted. By the first of October most of the fish that were in the river in August are dead.

And again:

> At the spawning season the changes, especially in the male salmon, are very marked. Both sexes lose their bright and silvery coat. Their scales become absorbed into the skin, which grows very slimy and perfectly smooth, like that of a catfish or hornpout. Their color changes into a dirty black, and then into a dark, unclean olive color. Blotches of fungus and large patches of white, caused by abrasion of the skin, appear all over them. The fins and tail become mutilated. Their bodies grow foul and emaciated. Their eyes get more or less injured; they often become blind; swarms of parasites gather in their gills and stick to their fins. Their bodies reach the extreme point of attenuation, and, as soon as the spawning is accomplished, they die.

No anadromous fish varies so much in size as the quinnat salmon, and this is one of its most notable characteristics. In the Sacramento the average weight at Sacramento City in 1892 was thought to be about 20 pounds, and the largest weighed 60 pounds. In the Columbia the cannery men put the average weight at about 23 pounds, and the largest on record weighed 83 pounds.

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[1] "The Chinook Salmon:" Transactions of the American Fisheries Society, 1894.

In the Yukon 100-pound salmon are said to be not rare, and the writer met on Kadiak Island a professional salmon fisherman who said he had seen a Yukon salmon that weighed 125 pounds. The smallest quinnat salmon that the writer has ever seen weighed $3\frac{1}{2}$ pounds, and was a female with perfectly developed ova, which were taken and afterwards hatched into healthy young salmon fry.

The salmon that are taken at Baird station, on McCloud River, in California, vary widely in size in different years. Leaving out the grilse, or partly matured males, the average weight of the salmon manipulated at this station the last few years is estimated at about 13 pounds each. On the other hand, in 1878, the average weight of the spawners taken in August, after the eggs had been expressed from them, was only $8\frac{1}{4}$ pounds.

Below will be found the weight of 82 salmon spawned and weighed after spawning, on the 29th of August, 1878:

Number.	Weight in pounds.	Number.	Weight in pounds.	Number.	Weight in pounds.	Number.	Weight in pounds.
1	16	22	17	43	5	64	5
2	8	23	7	44	5	65	6
3	10	24	7	45	7	66	8
4	9	25	8	46	7	67	7
5	14	26	15	47	8	68	7
6	6	27	9	48	7	69	5
7	12	28	8	49	7	70	5
8	7	29	7	50	7	71	7
9	8	30	11	51	6	72	6
10	7	31	14	52	8	73	7
11	8	32	14	53	9	74	7
12	15	33	7	54	6	75	7
13	7	34	17	55	6	76	7
14	8	35	13	56	5	77	6
15	6	36	8	57	8	78	11
16	8	37	7	58	7	79	5
17	7	38	9	59	7	80	7
18	7	39	14	60	7	81	8
19	7	40	5	61	10	82	5
20	8	41	7	62	6		
21	7	42	17	63	8		

In the Sacramento and the Columbia the appearance of the salmon is very regular, the numbers, however, showing a very marked dependence on the number of young fry hatched at the breeding stations the corresponding years.

There has never been to the writer's knowledge a serious failure of the salmon in any year to make their appearance in the Columbia, and only one instance of failure in the Sacramento, viz, in 1866, which was doubtless caused by the débris (slickens) turned into the river by the operations of the hydraulic miners.

In ascending the rivers the males usually precede, followed closely by the females. This continues through the season, in consequence of which, at the end of the season at a breeding station, there are usually females left over after the run of males has ended.

The rate of progress of these salmon up the rivers varies at different seasons of the year. In ascending the Columbia, they are usually from one to three weeks passing from the mouth of the river to Clifton, about 20 miles. They first appear at The Dalles in the middle of April, about two months after their first appearance at the mouth of the Columbia. They appear in great quantities at The Dalles about the middle of June, or two months after they appear in large numbers at the bar. The falls of The Dalles are 200 miles up the river, which would indicate that their rate of progression to that point is about 100 miles a month.

It will be noticed, however, that these statements are made in regard to the early run of salmon. The later fish probably travel more rapidly, and the fall run, in the Sacramento at least, make very quick time from the mouth to the headwaters of the river.

To what extent the salmon in the ocean are destroyed by larger predaceous fish is, of course, not known, but there is no doubt that great numbers are destroyed full grown at the mouth of the Sacramento by seals and sea lions. After the salmon ascend the rivers they are comparatively safe, except from otters and ospreys and fisher cats, but the number that these destroy is very small compared with the whole.

Strange to say, the quinnat salmon is spawning somewhere on the Pacific Coast waters of the United States seven months in the year. In January they are spawning in Eel River; in July the summer run are spawning at the headwaters of the McCloud and Little Sacramento; in August and September farther down these rivers; in October the fall run has begun at the McCloud and below, and this run continues spawning through November and into December.

In the Columbia and its headwaters there is, so far as I can learn, only one spawning season, beginning at the headwaters possibly as early as July. At Clackamas station, 125 miles from the mouth of the Columbia, they begin to spawn about the middle of September and continue until November.

When the salmon are prime (just from the ocean), both sexes look very much alike—in fact, they are almost identical in their appearance; but as the spawning season approaches, and they gather on the spawning-grounds, the difference in the looks of the males and females becomes more and more marked, and during the spawning season the difference is very conspicuous.

The now fully developed ova of the female gives her sex a peculiarly rounded and plump appearance, but the shape and expression of her head does not change much. On the other hand, the male grows very deep and thin. His head flattens, his upper jaw curves like a hook over the lower, his eyes assume a peculiarly sunken and malicious expression. Large, powerful white teeth, like dogs' teeth, appear on both jaws, and the whole creature acquires an ugly and ferocious appearance.

A few days before they are ready to spawn they hollow out cavities with their heads and tails in the gravel beds of the river where there is a vigorous current, and here in due time the eggs and milt of the parent fish are deposited. They cover the eggs to a certain extent after they are deposited, but not so much as eastern salmon (*S. salar*) do. After spawning, they gradually drop down the river with the current.

The quinnat salmon is not so prolific as the Atlantic salmon, 300 or 400 eggs to each pound weight of the parent fish being about a fair average. An early report of the writer placed the average much higher, but there must have been some mistake about it, for subsequent observations have not confirmed the statement. At Baird station the summer run of salmon usually begins to spawn about the 20th of August and continues until the last week in September. The fall run begins to spawn about the 25th of October and continues probably till Christmas or later, the high water at that season rendering it impracticable to ascertain just when the spawning of the fish ceases.

The eggs are about five-sixteenths of an inch in diameter, and of a deep salmon-red color, with a specific gravity sufficiently greater than that of water to cause them to sink at once to the bottom when placed in water.

The first eggs of the summer run taken at Baird station hatch in about 35 days, in an average water temperature of about 54° F. In their natural spawning-beds in the river itself, the eggs of the summer run are probably all hatched by the first week in December, and most of the eggs of the fall run by the 1st of March.

It is not known what percentage of eggs is hatched in the natural beds of the river, but by careful impregnation 95 per cent or more can be hatched artificially, even when the hatching is conducted on a large scale. Very little trouble is experienced in hatching the eggs, and when they are hatched no more beautiful sight can be imagined than that of the swarms of young, exquisitely colored alevins in the hatching-troughs. The alevins also remain very healthy with a suitable supply of water, and in two or three weeks develop their singular instinct to dive down underneath everything that they can get under. In consequence of this instinct, when left to their natural conditions in the rivers they bury themselves under the gravel bed of the stream, where, although without any means whatever of defense or escape and utterly helpless, they are nevertheless, by this wonderful provision of nature, absolutely safe until, their yolk sac having become absorbed, they have to come out of their places of refuge to get something to eat.

After the young fish come out of their hiding-places in the gravel, they at first gather together in schools, but soon begin to separate, after which they are so rapid in their movements that it is a pretty active bird or fish that succeeds in catching many of them. In the course of the summer following the hatching season, they flock together like blackbirds in the fall, and make their journey to the sea; and the next time we see them they are ascending the rivers to continue their endless round of reproductive life.

I can not close this subject without referring to the mystery which hangs over the question of the length of the stay of the quinnat salmon in the ocean. The problem is this: There is not a shadow of a doubt that more than nine-tenths, if not ninety-nine hundredths, of the summer run of salmon that come up the tributaries of the Sacramento to spawn end their lives immediately after spawning, but the next year, before their progeny are 6 inches long, another set of full-grown, mature salmon come up the river and spawn and die, and the next year the same, and so on. Now, the question is, Where did this second lot and third lot come from, and *where were they the year before they came up to the spawning-grounds?* If, being anadromous fish, all the Sacramento quota of salmon in the ocean came up to spawn any one year and died on the spawning-grounds, how could there be any run to come up the next year and the next? It seems almost as puzzling as the old question, Which came first, the hen or the egg? If the hen laid the first egg, where did the hen come from?

The mystery in regard to the salmon has so far remained unsolved, and probably will remain so for some time to come. The writer does not claim to furnish an answer, but would merely suggest that it may be possible that out of each annual batch of eggs that are hatched different portions of the fish created from them may remain in the ocean different lengths of time before they reach the reproductive stage of life, which hurries them up the rivers to perpetuate their species. This would supply a solution of the problem, but, like the theory of evolution, it is not at present supported by evidence.

THE ARTIFICIAL PROPAGATION OF THE RAINBOW TROUT.

By GEORGE A. SEAGLE,

Superintendent of the United States Fish Commission Station at Wytheville, Va.

VIEW OF WYTHEVILLE STATION, SHOWING BREEDING PONDS, WITH HATCHERY AND CARP PONDS IN THE BACKGROUND.

4.—THE ARTIFICIAL PROPAGATION OF THE RAINBOW TROUT.

By GEORGE A. SEAGLE,

Superintendent of the United States Fish Commission Station at Wytheville, Virginia.

The following brief treatise on the most modern and successful plans for the artificial propagation of the rainbow trout (*Salmo irideus*) has been prepared for the information and instruction of all who appreciate the advantages of fully stocking our streams with suitable fishes, thereby increasing the extent and variety of our food products and lessening their cost. It is written from an entirely practical standpoint, and it is hoped that with the aid of the accompanying illustrations all the necessary information will be conveyed in such a manner as to enable those interested in the subject to appropriate it to their own use and advantage. We have avoided, as far as possible, the use of scientific and technical terms and have attempted, in the plainest and simplest manner, to state the habits of this interesting and important species of fish and the methods by which they are now successfully propagated artificially at the Wytheville Station, explaining the design and construction of the requisite apparatus, the manner of building the ponds, and giving such other information as has been gained by 14 years of experience in the practical part of this work.

This fish is not indigenous to our eastern waters. Its original habitat was the Pacific Coast, extending from Mexico to the Canadian border, and possibly still farther north. In this extensive section of the West its name varied with different localities; "redsides," "mountain trout," "brook trout," "golden trout," etc., were some of the appellations; but in the States east of the Mississippi River the names generally given are "rainbow trout" or "California trout." It was first introduced into the eastern waters by the United States Fish Commission in 1880, but it is probable that specimens of it or its spawn were brought here prior to that time by some of the State commissions or by private enterprise. Be this as it may, the Wytheville Station was one of the first Government hatcheries to rear and handle them, and it was here that the writer made their acquaintance in the spring of 1882.

Size.—This depends chiefly upon the waters in which they are found, the size of the stream, the temperature of the water, the amount of food it contains, etc. The average weight of those caught from streams in this locality is probably less than a pound, but some weighing $6\frac{3}{4}$ pounds have been taken. In the Ozark regions of Missouri they reach a weight of 5 to 10 pounds. In some of the cold mountain streams of Colorado their average size would not be more than 6 or 8 ounces; while in lakes in the same locality, where the water is moderately warm in summer and food is plentiful, they grow to weigh 12 and 13 pounds and reach a length of from 25 to 28 inches. In Au Sable River, in Michigan, they attain a weight of 5 to 7 pounds. In their native streams of California they are often caught ranging in size from 3 to 10 pounds, but the average would probably be from 1 to 2 pounds. The largest specimen ever produced in the ponds at the Wytheville Station, and fed artificially, weighed $6\frac{1}{2}$ pounds, but many others in the same pond will weigh from 1 to 3 pounds.

Rate of growth.—The average growth, under favorable circumstances, is about as follows: One year old, from $\frac{3}{4}$ to 1 ounce; two years old, from 8 to 10 ounces; three years old, from 1 to 2 pounds; four years old, from 2 to 3 pounds. They grow until they are 8 or 10 years old, but the rate of growth diminishes with age. Some will grow much faster than others under any circumstances, but it may be truly said that the rate of growth is a question of food and temperature of water. In water at 60° and with plenty of food, fish one or two years old will double their size several times in a single season; while in water at 40° and with food limited, the rate of growth would probably be less than 100 per cent in the same time.

Temperature of water.—Mr. Livingston Stone says of brook trout:

> Under this head it may be suggested that the quantity and force of current and vigor of the water have much to do with the degree of temperature at which trout will live. For instance, when water does not possess much vigor, is deficient in quantity, and sluggish, it will not support trout in so high a temperature as when it is vigorous, plentiful, and rapid. I think it is safe to say that sluggish flat water at 70° is dangerous, if not fatal, to trout, while they will live in vigorous, rapid water which occasionally runs to 80°. I have found 85° to be fatal to them in all kinds of water. (Domesticated Trout, pages 13 and 14.)

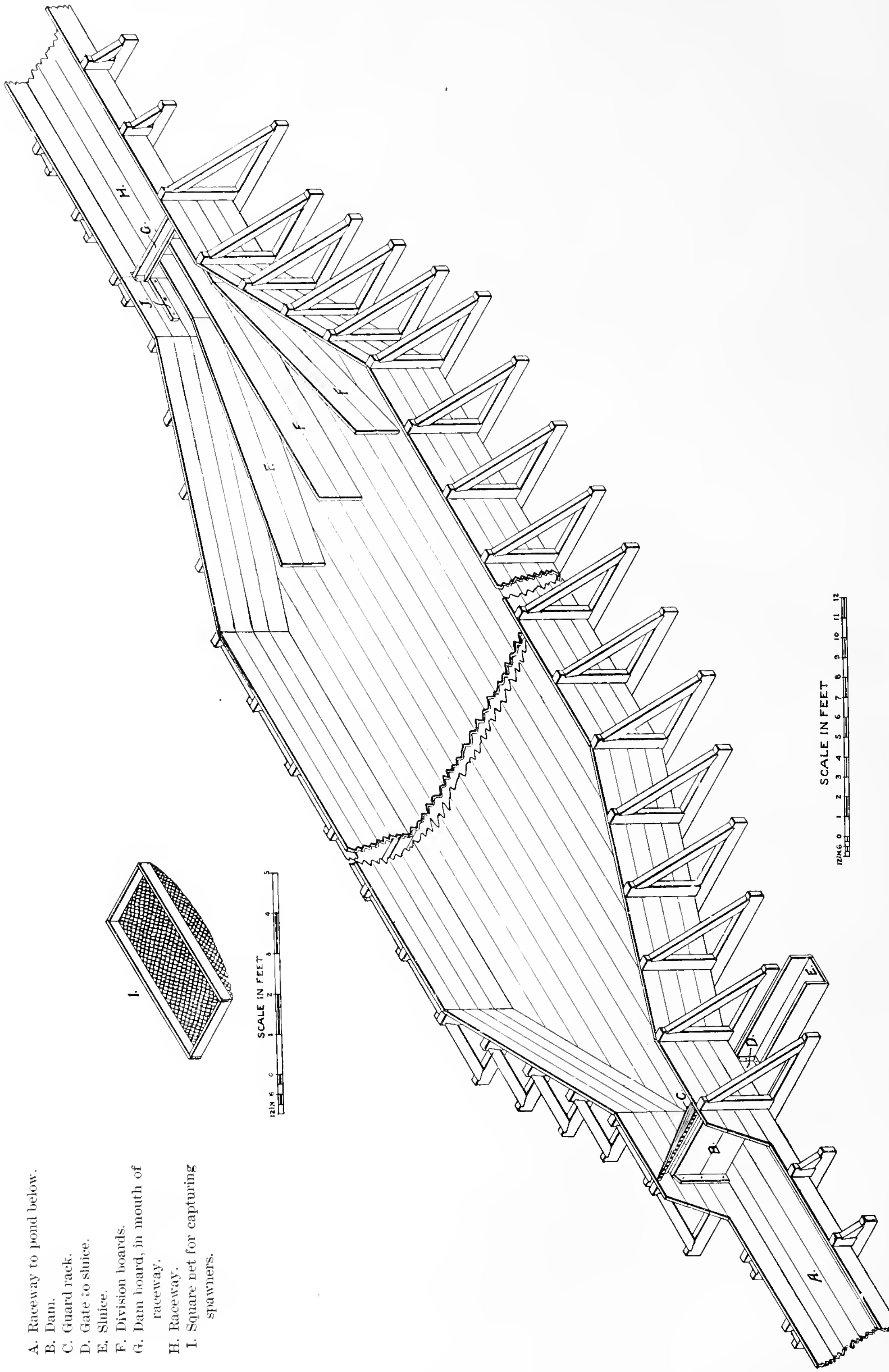
The above will apply, in the main, to rainbow trout also; rainbow trout will live, however, in warmer water than brook trout; they will thrive in "vigorous" water at 85°, especially where there is some shade; in ponds I would consider that temperature dangerous, even with shade and a fairly good current.

Edible qualities.—The trouts are generally recognized as being the best of all pan fish; but, as regards their relative value in this respect, there is difference of opinion. In comparing the rainbow trout with the brook trout (*Salvelinus fontinalis*), I find that conflicting reports come from all sections; even in the same locality I find much difference of opinion, so it may be said that it is all a matter of individual taste. Some regard the brook trout as having the finer flavor; others think that the rainbows are deserving of that distinction, while still others think there is no difference in the flavor of the two species.

Gamness.—The rainbows are quite game; they are active biters, and make a strong fight for their liberty.

Spawning-ponds.—The construction of the spawning-ponds, with reference to their shape and size, is of vast importance to the trout-culturist. I regard the best size for these ponds about 15 by 50 feet, and from 3 to $3\frac{1}{2}$ feet deep, constructed entirely of wood and shaped as shown in plate 89. A pond shaped in this way gives the best possible water circulation in all its parts, and there are no corners for the excrement and other foul matter to lodge in. The bottom of the pond should be built with a gradual elevation toward the upper end of about 2 inches in the length of the pond. This makes the pond practically self-cleaning; nearly all the foul matter will work through, and what is left in it can be easily gotten rid of by drawing the water down low, and letting the fish work it out. This saves handling the fish, which is very important, especially when it is near their spawning time.

Guard-rack.—This should be put in on an incline of about 45 degrees and made of thin narrow slats, as shown at C (plate 89). If the water is to be used over again in ponds below, a receiver should be built underneath the bottom of the pond at the lower end, between the foot of the guard-rack and the dam-boards. The floor of the pond immediately over this receiver is to be cut away and a grating set in. This will allow matter to fall through into the receiver and from there be washed out through the



A. Raceway to pond below.
B. Dam.
C. Guard rack.
D. Gate to sluice.
E. Sluice.
F. Division boards.
G. Dam board, in mouth of raceway.
H. Raceway.
I. Square net for capturing spawners.

SPAWNING POND.

sluiceway, which taps the receiver, by drawing the gate, shown at D. I prefer to have the sluiceway (E, plate 89) covered and led off under ground to a general waste-ditch, or it can lead to any point desired.

Raceway.—The pond should be constructed with a spawning-race 1 by 4 feet, and about 25 feet long, placed at the upper end of the pond, as shown at H. This should be cut in its depth (1 foot) from the top of the pond, as shown in the illustration. Three division boards (shown at F), about 12 feet long and of suitable width to come within 2 inches of the surface of the water when the pond is filled, should be firmly fixed to the bottom of the pond. The object of these boards is to form four avenues leading to the raceway, so that one or two pugnacious fish (partly stripped spawners are the worst) can not command the entire approach to the raceway and keep back spawners inclined to enter. There should be a dam across in the mouth of the raceway, about 4 inches high (shown at G), for the purpose of bringing the water to that depth in the lower end, so that spawners that enter may have sufficient water to swim around in and feel free, and not be inclined through fear to return to the pond.

Depth of water in the pond.—The water in the pond should be of sufficient depth to bring its surface within 6 inches of the top of the dam in the raceway; this will give the fish, in entering the raceway, a jump of about 7 inches, allowing 1 inch for the depth of water on the dam in the raceway. I have found that distance more satisfactory than any other; at that distance spawners will enter freely, and without difficulty, and only spawners will go up. If a jump of much less than 7 inches is given, so that fish can enter the raceway without some exertion on their part, fish of all classes will go up, many apparently through mere curiosity, with no inclination to spawn. This is very undesirable, as the spawners prefer to be by themselves; if they did not they would probably not go up the raceway at all.

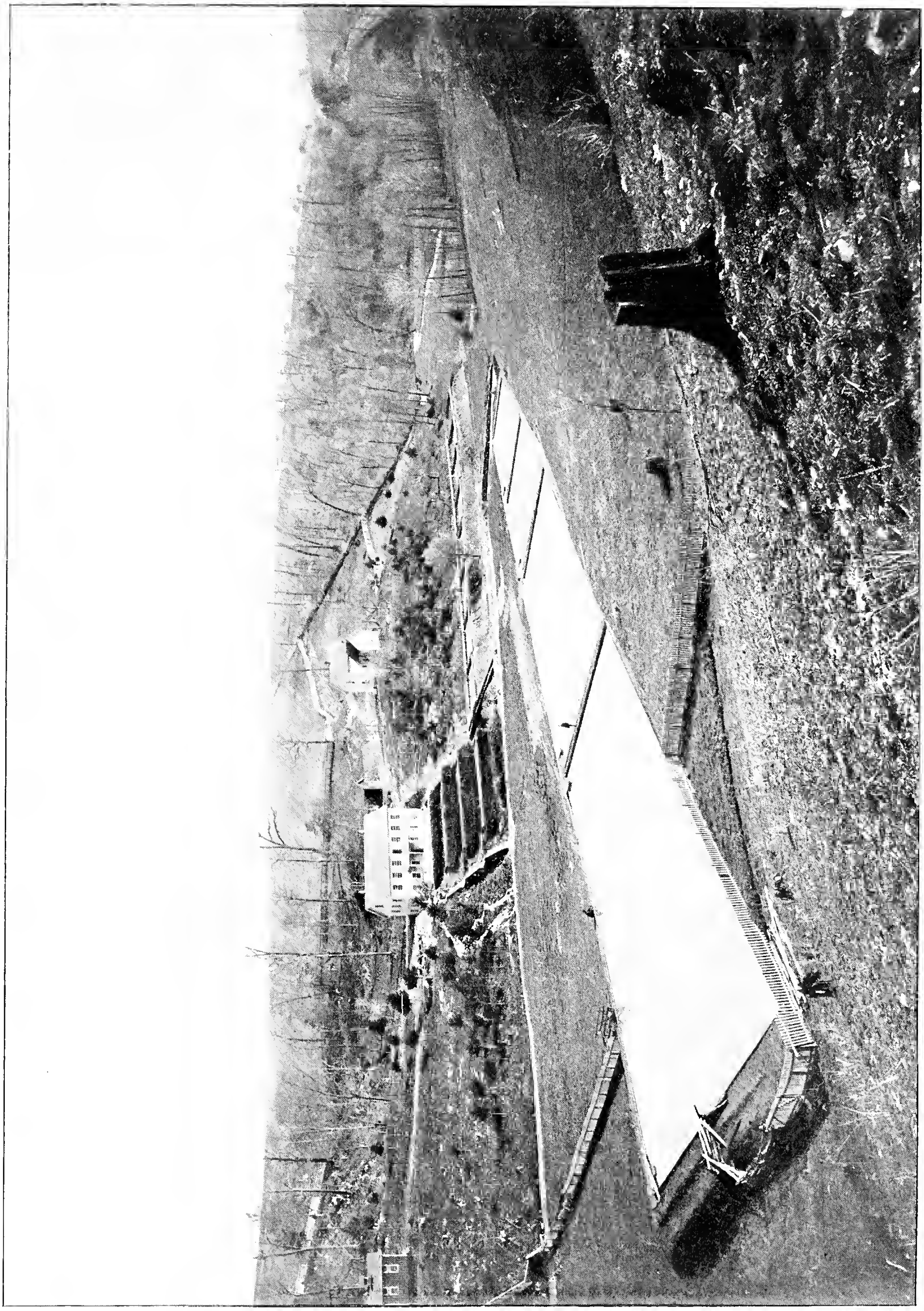
Stocking the pond with breeders.—For a pond such as I have described (15 by 50 feet) I would recommend from 1,000 to 1,500 fish; this, however, is a question that every trout-culturist must decide for himself, as there are several things which should govern it, such as the size of the fish, water supply, temperature of water, amount of shade, etc. The fish will not thrive so well if crowded. As regards the proportion of sexes in stocking the spawning-pond, I prefer the ratio of two-thirds females and one-third males. I consider that a larger number of males are a disadvantage. They are in the way in every respect; better cull them out at spawning time and give the room they occupy to more females. I also strongly recommend culling the breeding stock every year and throwing out all the males that will not be needed for the next season. Keep only young males when you have them; they are preferable. Throw out the blind and emaciated fish of both sexes; they can not be of any service to you. It is only the perfect specimens that it pays to keep.

Food.—Trout, as is well known, are not naturally vegetarians; in fact, they are generally supposed to be strictly carnivorous, and when a plentiful and cheap meat diet can be gotten, I do not think it can be improved upon; but this can not always be obtained in sufficient quantities and at a price that will justify its exclusive use. In that case I would recommend a mixed diet of liver and mush, prepared as follows: Make a mush of wheat shorts, or middlings, and boiling water, by stirring the shorts into the boiling water until it is as thick as it can be mixed well. As soon as it is cool it is ready for use. This mush will keep for several days, even in warm weather, by keeping it in a cool place. After grinding or chopping the liver fine, mix in the mush thoroughly, in any desired proportion, up to four-fifths of the whole. At Wytheville,

when liver is plentiful the food is mixed two-thirds mush and one-third liver. When this kind of meat is scarce it is mixed to suit the amount of it available. I have fed this vegetable and meat mixture to trout at the Wytheville Station for 13 years, and it has proven entirely satisfactory. Since its introduction at Wytheville it has also been tried by Mr. W. F. Page, superintendent of the Neosho station, and others, with satisfactory results. For grinding or chopping the liver, I do not know of a machine that is equal to the Enterprise meat-chopper. I have had one of these machines in use for eight or ten years, and I find that it does its work in the best possible manner, as there are no strings or chunks left to choke the fish. There are several sizes of this machine made, with extra perforated plates, having different-sized holes, from one-twelfth to one-fourth of an inch in diameter, so that the meat may be prepared coarse or fine, to suit the size of fish. For the small fry it will be necessary to use the plate having the smallest holes and to grind the food over two or three times, until it is made fine enough for use.

Feeding the fish.—The method generally practiced is to throw the food into the pond by handfuls, or by dipperfuls. I consider this method altogether wrong, as it causes the fish to come together in great numbers and in a rough-and-tumble manner; and in struggling with open mouths to get a bite of the food they often scar themselves up, injure one another's eyes, and sometimes pluck them from their sockets. This I consider one of the main causes of blindness among pond-fed fish. The method of feeding which I would recommend is to walk along the pond its entire length to the upper end; the fish will soon follow; then take a handful of the food and throw it underhanded down the pond; this will cause the food to skim along the surface of the water, come to pieces, and scatter in every direction. The fish will follow the food and take up what was thrown out, and then return to the head of the pond to watch for the next handful. Repeat the operation again and again until the work is finished. In following this method of feeding, the fish are not brought together in an abrupt manner, the food is well scattered over a good portion of the pond, and the fish are all heading in the same direction while they are feeding, thereby saving their eyes, and avoiding bruises and scars. The amount of food for a given number of trout must depend upon the size of the fish and the temperature of the water. Fish will not take food as freely in a low temperature as they will when the water is warmer. With water ranging in temperature from 50 to 60 degrees I would recommend for 1,000 yearling fish, ranging in size from 3 to 5 inches long, about three-fourths of a pound for their daily ration, while for the same number ranging in size from 8 to 12 inches about 12 pounds per day will be required. I prefer to have my fish fed twice a day, at regular hours morning and evening, giving half of the above-stated quantity at each feeding. This will keep the fish in a thrifty and growing condition. As the fish increase in size the amount of food should be increased proportionately.

Amount of water necessary for a spawning-pond.—There is no rule, so far as I know, that will apply to this matter at all times and in all places. It must necessarily be governed by the temperature of water, size and shape of the pond, and the number and size of the fish to be supported, the amount of shade, etc. For a spawning-pond, such as I have described, where the water is plentiful, I would give at least 200 gallons per minute. Not that I consider that amount necessary for the support of the fish, but the pond will be kept cleaner and the fish will enter the raceway better at spawning time. Under no circumstances would I give, with water ranging from 50 to



GENERAL VIEW OF WYTHEVILLE STATION FROM RAILROAD TRACK.

55 degrees and with all other conditions favorable, less than 75 gallons per minute. I consider that amount about the minimum for a pond built and stocked as I have recommended. In order to maintain an even temperature in the ponds they should be banked against the sides and ends with earth, which, of course, covers the framework that is shown in plate 89. The embankments should be broad enough on top to admit of a good walkway around the ponds.

Spawning season.—The spawning season varies with the locality and the temperature of the water. It is usually two to four weeks later in the streams than where the fish are kept confined in spring water. In the ponds at the Wytheville Station we expect to find spawners any time after the 1st of November; the season is well started by the 15th, and it generally closes about the 1st of March. December and January are our best months. In California the season runs from the 1st of February to May, and in Colorado it begins early in May and probably extends to July.

Natural spawning.—I have never had an opportunity of seeing the rainbows spawn naturally in the streams, but I have found their nests in our ponds and raceways at this station when it used to be our custom to keep gravel in the raceways for the purpose of inducing the spawners to enter. We do not use gravel about the ponds or raceways now. These nests were about the size of a dinner plate, the gravel forming them being concaved to make a depression in which the eggs were deposited. After being fertilized by the male fish the eggs would be lightly covered over with small gravel, and in this condition they are left to their future destiny.

Artificial spawning.—Where spawning-ponds are provided with suitable raceways, the fish will ascend from the ponds into them, seeking a place to make their nests. They are then ready to be taken out and their spawn expressed. To take the fish from the raceway, drop the square net (I, plate 89) in on the cleats which are nailed against the side walls in the approach, shown at J; then raise the dam in the mouth of the raceway and scare the fish back into the net; this being accomplished, lift the net out and pour the fish gently into the spawning-tub, which should always be at hand ready for use. If more fish are in the net than can be lifted out at one time, use a landing net to take out a part of them before moving the square or spawning net. Never put too many fish in the tub at one time; they will become restless and sick before you can handle them and strip them of their spawn.

Taking the spawn.—There are two methods in general practice in taking and impregnating the spawn of fishes; one is to allow the eggs to fall into a pan containing more or less water, to be immediately followed by the milt or seminal fluid of the male fish, mixing the milt well with the water and eggs in the pan. The other is known as the Russian or "dry" method. The water is omitted and the eggs are taken in a dry pan with the milt. In this case it makes but little difference which is taken first, the eggs or the milt, but the one should immediately follow the other and they should be thoroughly mixed together in the pan. After giving the milt and eggs time enough for thorough contact, but before the eggs begin to adhere to the bottom of the pan, add water to the depth of about 1 inch in the pan, and let the eggs remain two or three minutes longer, keeping them moving gently by turning the pan to prevent adhesion. This being accomplished, pour the milt off and add clear water to the pan, allowing the eggs to remain until they separate, which will be in from 10 to 20 minutes. If it is convenient to take the eggs to the hatchery, before time for pouring off the milt and water, I prefer to rinse them off there and then place them on the hatching-trays, which have been previously arranged in the water in the hatching-troughs,

allowing them to separate there.[1] Both of these methods have been thoroughly tried at Wytheville, and each proved satisfactory when the spawners were in good condition and the work was well done, but I am inclined to favor the "dry" method under most circumstances, as it seems to give the best results.

If the weather is freezing cold, I prefer either taking the eggs in water or using two pans, one set in the other, with water from the pond in the bottom pan to prevent the eggs from being chilled. To manipulate the fish in taking the spawn and to do it without injury to the fish, is a very delicate and particular task, and one that requires experience. Almost anyone can squeeze the spawn from the fish, but to do it without injuring or even killing the parent fish, is something that very few spawn-takers ever learn to do. In taking hold of the fish, after they have been placed in the spawning-tub, it is best to catch the spawner by the head with the right hand, having the back of your hand up; at the same time slip your left hand under the fish and grasp it near the tail, between the anal and caudal fins. A fish caught in this way can be easily turned over, as it is brought out of the water, so that its abdomen will be up and in the proper position for spawning by the time the spawning-pan is reached. If the fish struggles, hold it firmly but gently, until it becomes quiet. If you have it in the right position it will struggle only for a moment. If the fish is a large one, put its head under your right arm, and when the struggle is over, pass your right hand down the abdomen until the point midway between the pectoral and ventral fin is reached; then with the thumb and index finger press the abdomen gently, at the same time slipping the hand forward toward the vent.

If the eggs are ready to be taken they will come freely and easily. If they do not come in this manner, put the fish back in the pond for some future time. If the eggs come freely from the first pressure, slip your hand back and repeat the operation, beginning at or near the ventral fin. After the first pressure has been given, by holding the head of the fish higher than the tail, all of the eggs that have fallen from the ovaries and are ready to be expressed will fall into the bottom of the abdomen, near the vent, so that it will not be necessary to press the fish again over its vital parts, the eggs having left that part of the body. All of the eggs that have fallen into the abdomen below the ventral fin can be easily expressed, and without danger of injuring the fish. The danger lies in pressing the fish over its vital parts after the eggs have left that part of the body. If this method and these directions are judiciously and carefully followed, little if any damage will result to the matrons thus handled. As an illustration, I may mention the fact that I have kept fish for 14 years, and extracted from them a full quota of eggs each recurring season during their egg-producing term, which is from 10 to 12 years.

The male fish is to be treated very much in the same manner, taking only what milt will come freely. More milt is required in taking eggs by the "dry" method than when water is used, as enough should be in the pan to allow good circulation through all of the eggs. If only a small amount of milt can be gotten, use water to make up the required amount of liquid for this purpose. Very little milt will often give good impregnation, but when milt can be gotten plentifully, be sure that you use enough to give good results. After stripping the fish of their spawn, remove them

[1]Some trout-culturists recommend letting the eggs remain in the milt and water until they separate, but, as it is generally acknowledged that the spermatozoa becomes inactive in 2 minutes after coming in contact with the water, I can see no good reason for leaving this dead milt on the eggs, as they must necessarily absorb it to become freed from the adhesion. I think it would be more natural for them to absorb only pure water.

from the spawning-pond, being careful to put the spent females in one pond and the males in another, as the males are very pugnacious about this time and are not very particular about what they fight.

Incubation and hatching of the eggs and care of fry in the hatchery.—The eggs of trout are usually incubated and hatched on trays, which are placed in the water in troughs and boxes of various sizes and shapes. I prefer troughs which are made and set in pairs, as shown at fig. 1. These troughs are about 15 feet long, and made of the best pine lumber, dressed to 1½ inches thick. The bottoms are 14 inches wide and the sides are 8 inches wide. The guard screen (A) should be put in about 14 inches from

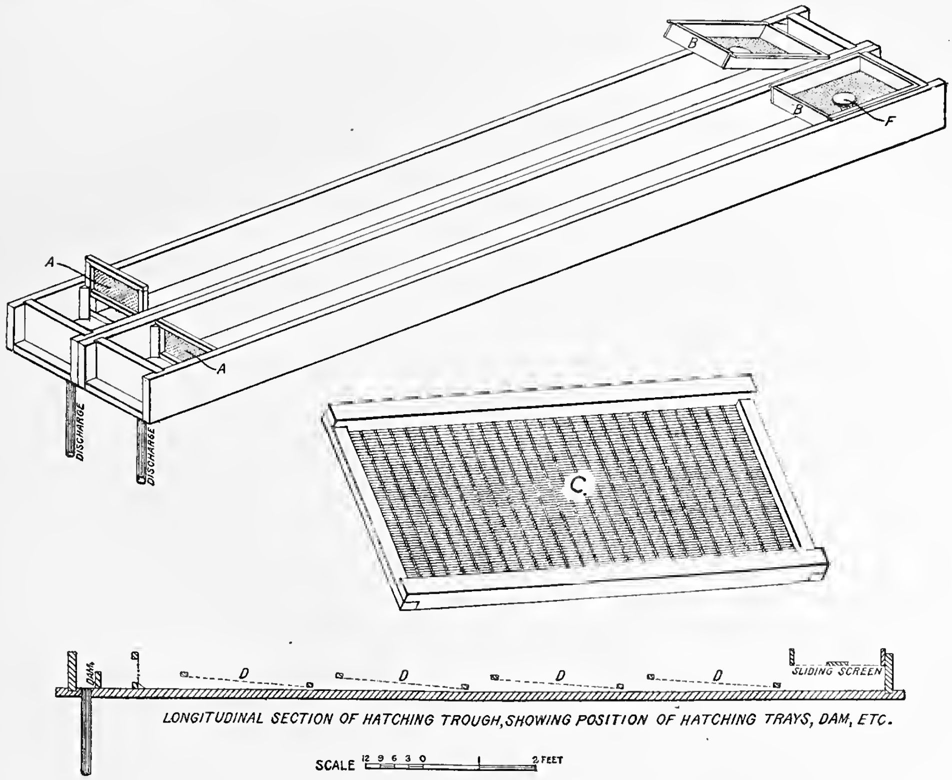


FIG. 1.—Hatching troughs, guard screen, etc.

A. Guard screen.
B. Horizontal sliding screen.
C. Hatching tray.
D. Position of hatching trays.
E. Tin tray for use in muddy water (see fig. 2).
F. Block for water to fall upon.
G. Brackets (fig. 2).
H. Feet (fig. 2).

the lower end (inside). It consists of a frame made as wide as the trough is deep and as long as the trough is wide, and put in with beveled lining on both sides at the end, but across the bottom the lining should be put only on the upper side; this will assist in keeping the parts clean. Instead of wire on the guard-screen, I prefer perforated tin, with perforations a sixteenth of an inch for very young fry, and larger perforations as the fish grow. The dam is put in from 4 to 5 inches from the lower end, and is simply a plain board 3½ inches wide. In the upper end of my troughs, I use horizontal sliding screens (shown at B) with perforated tin bottoms, instead of the vertical screens formerly used. The advantages claimed for the sliding screens are obvious;

the fish are allowed to pass up under the screen—the most important part of the trough—and there receive a shower bath, which keeps them clean even in muddy water; there is no jumping over the guard screens or the sides of the troughs, and there are no obstructions across the bottom of the troughs to cause the alevins (very young fry) to suffocate, as was so often the case when the vertical screens were used. In feeding the fish, or examining into their condition, the screens can be either slid back or raised out of the way, as shown in the illustration.

Hatching trays.—I prefer the hatching-trays made fully twice as long as wide, because they are then much easier to adjust in the troughs and hold more eggs, which, of course, makes fewer trays to handle and thus facilitates the work. The trays that I use are 13½ by 28 inches (shown at C, fig. 1). The sides of the frame are made of good pine lumber, dressed 1 inch square; the ends are dressed ½ by 1 inch, and are cut into the sides their thickness from the under side, forming a smooth surface on that side for the wire bottom. The wire used on the trays is woven with 8 threads to the inch, with a mesh ⅞ of an inch long. The wire should be well galvanized after it is woven, in order to prevent rusting at the laps.

Placing the trays.—Four hatching-trays are placed in each trough and are secured in place by means of keys or wedges, and should be from 1 to 2 inches lower at the end toward the head of the trough, as shown at D, D, D, D, fig. 1. In this way the trays will hold from 12,000 to 15,000 eggs with perfect safety. If we should be unfortunate enough to have muddy water during the hatching season, we use a tin tray with perforated bottom, shown at E, fig. 2. This tray is made 13¾ inches wide and 32 inches long, and sets inside of the hatching-trough on feet, H, raising it 1 inch above the bottom of the trough. The hatching-tray, containing the eggs that are hatching, is placed inside of the tin tray, and rests on the bracket shown at G. The little fish, as they hatch out, fall from the hatching-tray on the perforated bottom of the tin tray, and by their movements work the sediment through, leaving them on a clean bottom and in no danger of being smothered. These tin trays are also useful in counting fish, or in holding small lots of fish of different species in the same trough.

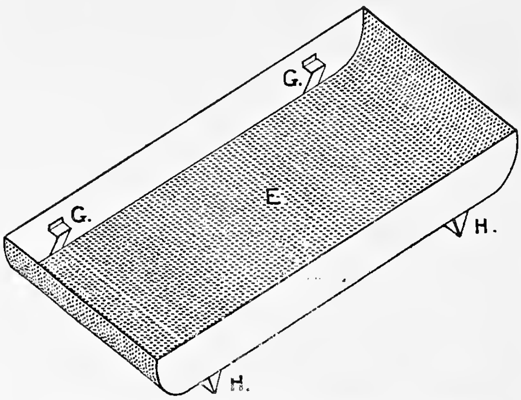


FIG. 2.—Tin tray for use in muddy water.

Number of eggs to a trough.—Troughs 15 feet long will admit of 4 hatching-trays in a single row; each tray will safely carry 12,500 eggs, making 50,000 eggs to a trough; this is enough to work easily, but if it is necessary in order to make more room a double row of trays may be put in, one tray resting on the top of the other. In this way the trough would contain 100,000 eggs, which I consider about its full capacity. The troughs will carry this number up to the time of hatching, by placing the trays lower at one end than the other, as previously described.

Care of the eggs.—After placing the eggs on the trays, they will need no further attention until the hatching begins, except to keep them clean and the dead eggs picked off. These dead eggs may be known by their turning white. The eggs should be examined once every day for that purpose. After the eye-spot can be plainly seen

it is a good idea to run a feather through the eggs for the purpose of changing their position on the trays and to disclose any dead eggs or foreign matter that may be hidden underneath. Great care should be exercised in handling the eggs at any time, but after the first or second day from the taking until the appearance of the eye-spot, they should be handled with especial care, and then only when it is absolutely necessary, as during this period they are very delicate, and a good shaking up, or even passing a feather through them, will cause a heavy loss.

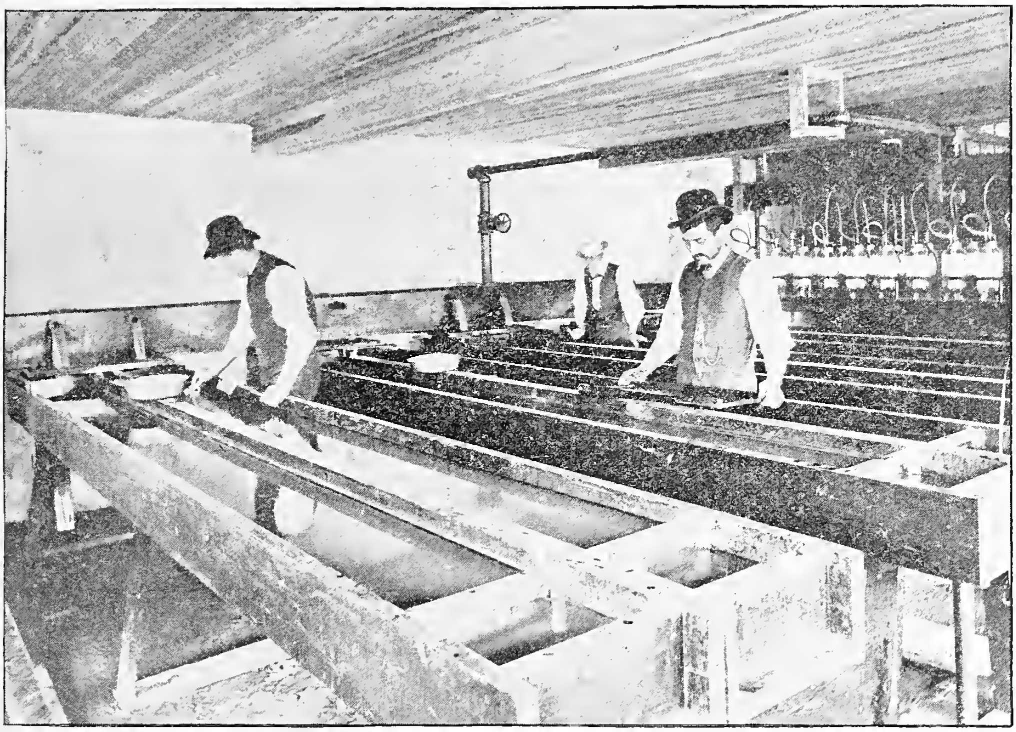


FIG. 3.--Interior view of Hatchery showing men fishing out Dead Eggs.

Time required to hatch the eggs.—The time required to hatch trout eggs, or fish eggs of any kind, depends almost wholly upon the temperature of the water in which they are placed. I do not know of any rule that can be depended upon in all cases. In "Trout Culture," by Mr. Seth Green (page 29), I find the following regarding the incubation of eggs of the brook trout:

> A rule sufficiently accurate for all practical purposes is this: At 50 degrees the eggs will hatch in 50 days; each degree colder takes 5 days longer, and each degree warmer 5 days less; the difference, however, increasing as the temperature falls and diminishing as it rises.

The above rule is as good as any that I know of, but it will not do to depend upon it in all cases. The rainbows, however, will hatch out from 2 to 5 days earlier in any case than the brook trout.

Hatching the eggs.—Two trays of 12,500 eggs each are as many as should be left in one trough for hatching; with this number in a trough—using my horizontal sliding screen in the upper end—there is but little danger of the alevins congregating

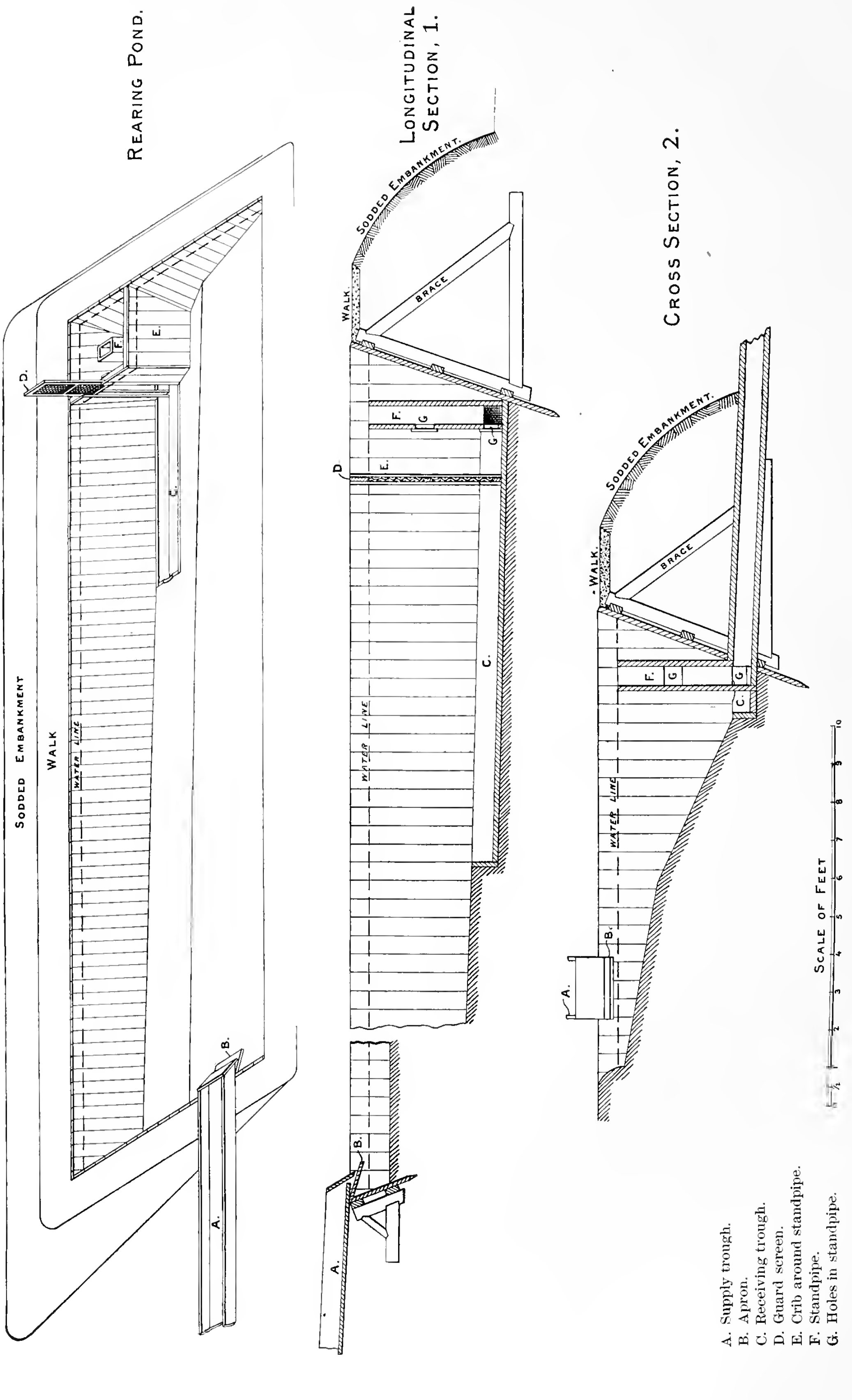
and smothering in any part of the trough. If it is necessary to hatch a much larger number in one trough, the sliding screen should be so arranged that the water will fall well up against the end of the trough. This can be done by raising the screen and turning it back against the reservoir, or by putting in a wedge-shaped block for the water to fall upon, turning the thin side of the block to the upper end of the trough. I have had 50,000 trout hatch in one trough prepared in this way, without any loss from suffocation. I would not, however, recommend hatching such a number together in one trough, if it can be avoided, as there will be too many to raise up to feeding time, and they would necessarily have to be divided before that time.

The young fry.—After the fry hatch out they will require but little attention until the yolk sac is absorbed and the time of feeding comes on. They should be examined each day, and the dead fish and other decayed matter removed from the troughs. The troughs should be kept perfectly clean and provided with a thin layer of coarse white sand on the bottom, which will serve in keeping the fish clean and in a healthy condition. As the fish grow they should be thinned out in the troughs from time to time, as their size may require. When they first begin to feed, 12,000 to 15,000 fish to the trough will not be too many; but by the time they get to be 1¼ to 1½ inches long they should be divided up, 8,000 to 10,000 to the trough, while with yearling fish, or fish averaging 3 inches in length, from 3,000 to 4,000 will be as many as one trough will carry. More room would be advisable in all cases if it is to be had.

Food of young trout.—Beef or sheep liver, ground or chopped to a fine pulp, is generally recognized as being the best artificial food for young trout. Other things have been tried, such as hard-boiled eggs grated fine, milk curds, etc., but liver seems to be the favorite article at present. Some efforts have been made to produce a natural or living food, but the results so far, I believe, have been unsatisfactory. This may yet be accomplished for late spring and summer feeding, but for feeding the fry during the first three or four months of their lives, which is in the winter season, I think we will have to be contented with something besides a living food, and for this purpose I can recommend nothing superior to the liver diet, unless it be fish eggs.

Fish eggs as food.—During the spring of 1895 the idea was conceived of having shad and herring roe put up in tin cans to serve as food for young trout. One case (2 dozen 1-pint cans) was sent to me at Wytheville Station, but as I did not receive it until the first part of June, and my fish were then all good-sized fingerlings, I was not successful in getting them to eat it at that time, as they seemed to be looking for something larger than herring roe. I concluded then that I would keep over a few cans and try it the following season (1895–96), while the fish were yet small. This I have now done, and the result has been very satisfactory. I am sorry that I did not have enough roe this season to prosecute the experiment further; but my experience has been sufficient to convince me of its merits and to cause me to believe that it is a more wholesome diet for young trout than liver, since it does not pollute the water in feeding and the fish grow to be extremely fond of it. I am of the opinion that fish roe will hereafter form a good part of the food for young trout that are reared in confinement. I understand that it can be gotten during the fishing season in large quantities.

Feeding the fry.—In my opinion the feeding of young fry is the main point in successful trout-breeding and the part in which we are most likely to err. I believe that more young trout die from improper feeding than from all other causes put together; and the reason for it consists in too much haste in feeding or else in distributing



REARING POND.

the food in such manner as to prevent each one from getting its proper share. If liver is used as food it is very difficult to distribute it evenly through the water so that all the fish will partake of it without the water in the trough being made milky from its use. This is very objectionable and, in my opinion, very injurious to the young fish. I think that it produces inflammation of the gills and a slimy, itching disease of the skin, often causing heavy mortality among the young fish. The fry will be ready to take food as soon as the yolk sac is absorbed; the time required for this will depend upon the growth of the fish, superinduced by the temperature of the water. At Wytheville, where the water temperature is regular at 53°, they will take food in about 30 days after hatching. The time to commence feeding can be closely determined by watching the movements of the fish. Before the yolk sac is entirely absorbed they begin to break up the schools on the bottom of the trough and scatter through the water, rising higher and higher from the bottom of the trough each day until they can balance themselves gracefully in a horizontal position, all heading against the current and swimming well up in the water. They are then apt to be ready for food, but, to make sure of it, drop some small bits of cork or a nap from red flannel on the surface of the water, and if they strike at it as the current carries it down, give them food, but do not give it to them until they strike at the substance floating.

Their food should be prepared very fine, and if it consists of liver it will be found necessary to put some water with it before feeding, in order to make it distribute evenly. The liver can best be given to the fish with a feather, by dipping the feather into the liver and skimming it over the surface of the water in the trough. After the fish grow to be $1\frac{1}{4}$ to $1\frac{1}{2}$ inches in length they will begin to take the food that settles on the bottom of the trough, and as it is then not so tedious and difficult to feed them the food can be given from the hand and it will not be necessary to mix it with water. The young fry should be fed five or six times a day, giving them their food slowly and sparingly. After they learn to take their food well from the bottom of the trough three feeds a day will be sufficient, as they can then be given more at each feeding.

The rearing ponds.—Ponds for rearing fish should be narrow, say from 8 to 12 feet wide, and any desired length, up to 60 feet. For convenience in drawing off the ponds, etc., I would not advise making them more than 60 feet long. The size, shape, and arrangement of the ponds must depend altogether upon the topography of the ground where they are to be constructed. If it can be so arranged, I prefer to have these ponds built on a hill-side, one pond above the other, with earth and piling embankments at the lower sides and at the ends. A pond of this kind is shown at plate 91, and is the one which I shall endeavor to describe. In the construction of these ponds various materials may be used for damming the water. The embankments may be made of earth altogether, or they may be lined on the inside next to the water with stone, brick, cement, or timber. In all cases they are constructed with the same end in view, and the general principle is very much the same. It is not always convenient to use certain materials, but where the ground is of a porous or loose formation it will be necessary to use piling or cement for the inside of the embankments, and possibly cement for the bottoms.

I prefer in all cases to have earth bottoms, where the nature of the ground will permit. The water should enter the pond at one end and discharge from the corner having the deepest water in the opposite end. The bottom should be graded as shown in the cross section 2, plate 91, and with a slope toward the outlet, so that all the

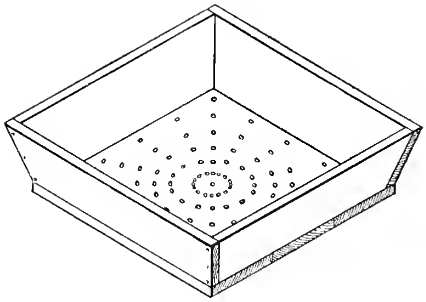
water can be drawn out, and in doing so the fish will be drawn into the receiving trough (C), which is placed with its top flush with the earth bottom in that part of the pond. The outlet for the water is an L-shaped pipe (shown at F, in cross-section 2), which is placed in the corner of the pond, the long end passing through the piling and underneath the pond embankment; the short end, called the stand-pipe, stands close in the inside corner of the pond in an upright position. The stand-pipe should have two or more holes cut through (G, in section 1, plate 91) on the side next to the receiving-trough, for the water to pass out in drawing down the pond. The size of these holes should be made in proportion to the size of the stand-pipe, which in turn should be governed by the size of the pond. The holes are to have a block of suitable size tacked over them to allow the pond to fill with water. A crib should be built around the stand-pipe, as shown at E. In the front of this crib is placed the guard-screen (D), which should be 15 inches or more in front of the stand-pipe.

The guard-screen should be from 14 to 16 inches wide, using wire cloth 2 inches narrower. The wire used on the screen should either be of copper or well galvanized. The size of the mesh in the wire should be suited to the size of the fish in the pond. The receiving-trough (C) should also be in proportion to the size of the pond. For a pond 10 by 40 feet a receiving trough 16 inches wide, 6 inches deep, and 10 feet long would be a good size. A portion of the trough, as wide as the guard-screen, should extend back and connect with the stand-pipe, the guard screen to fit down on the inside of the trough. If the work is well done this will make every part secure, and there will be no danger of losing fish in drawing the pond. The trough or pipe carrying the water into the pond must be so arranged that the fish can not jump from the pond into it. A good plan is shown at A, in the longitudinal section (plate 91); also at A, in rearing pond. This arrangement has been in use at Wytheville Station for a number of years and has given entire satisfaction.

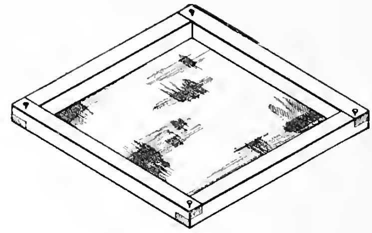
Stocking the rearing-ponds.—In stocking the rearing-ponds with trout fry I would strongly recommend doing it by degrees, especially where the feeding is to be done by hand. I would put 500 to 1,000 fish in the pond and train them to take food readily before adding to them; that number of fish can generally find enough natural food in the pond to subsist upon until they can be trained to take the food that is given to them. Then add another 1,000 fish, and in about 10 days 2,000 more may be added, and so on till the pond is stocked with the desired number. When fish are first released in the ponds they seem to be wild, and will run away from the food given to them; hence the necessity of teaching a few fish to eat first and then to add more from time to time. The first lot of fish being trained to eat, others will soon follow.

The number of fish that a pond of a given size will support will depend upon the amount and temperature of the water and the amount of shade furnished, etc. In a pond 10 by 50 feet, and with water from 3 inches to 3 feet deep, I would not put over 10,000 fish in any case, unless I was forced to do so for want of room.

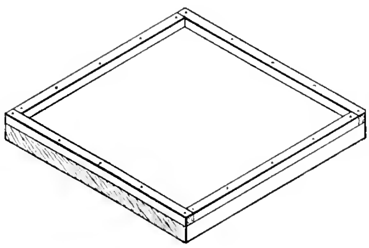
Packing eggs for shipment.—In packing trout eggs for shipment, they are usually placed on trays in wet moss. At the Wytheville Station, whence shipments are made to all parts of the United States and to many foreign countries also, the eggs are packed as follows: The number to be shipped is divided in from five to ten equal parts, according to the size of the shipment. If 30,000 eggs are to be shipped, I would use 10 trays large enough to contain 3,000 eggs each; if 15,000 eggs, I would have 10 trays containing 1,500 eggs each; 10,000 eggs, 8 trays of 1,250 each, etc. If over



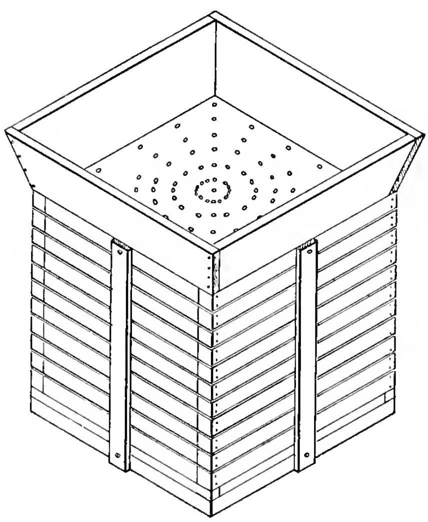
A



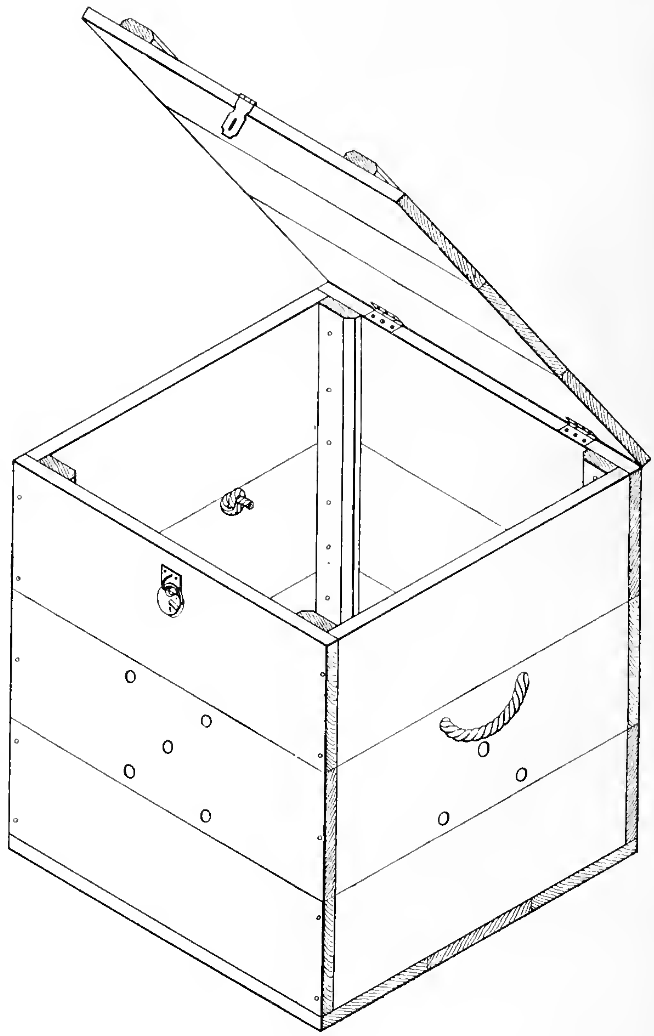
B.



C.



D.



E

A. Ice hopper.
B. Egg tray.
C. Foundation board.
D. Egg trays packed and cleated.
E. Outside case.

SCALE IN FEET

12IN. 9 6 3 0 1 2

[The scale of this figure also applies to figs. A, B, C, and D.]

APPARATUS USED IN PACKING AND SHIPPING EGGS.

30,000 eggs are to be shipped, I would divide the shipment in two lots and send two boxes. A package of more than 10 trays, especially if the trays are large, would be liable to crush the eggs on the lower trays by having too much weight above. If less than 5 trays are used in a shipment, the package is apt to dry out, and the eggs will reach their destination either dead or in a shriveled condition. The frames of the trays (B, plate 92) are made of light, soft lumber, dressed to $\frac{5}{8}$ by $\frac{7}{8}$ of an inch, and are bottomed with soft canton flannel stretched on tight and well tacked. The trays are made large enough not only to contain their proportional part of the number of eggs to be shipped in one layer deep, but allowance is made for a space of $\frac{3}{4}$ of an inch between the eggs and the frame of the tray.

A foundation board (C, plate 92) is made with outside dimensions same as the egg tray, and with a strip nailed around the edge on the top side to form a cushion of moss

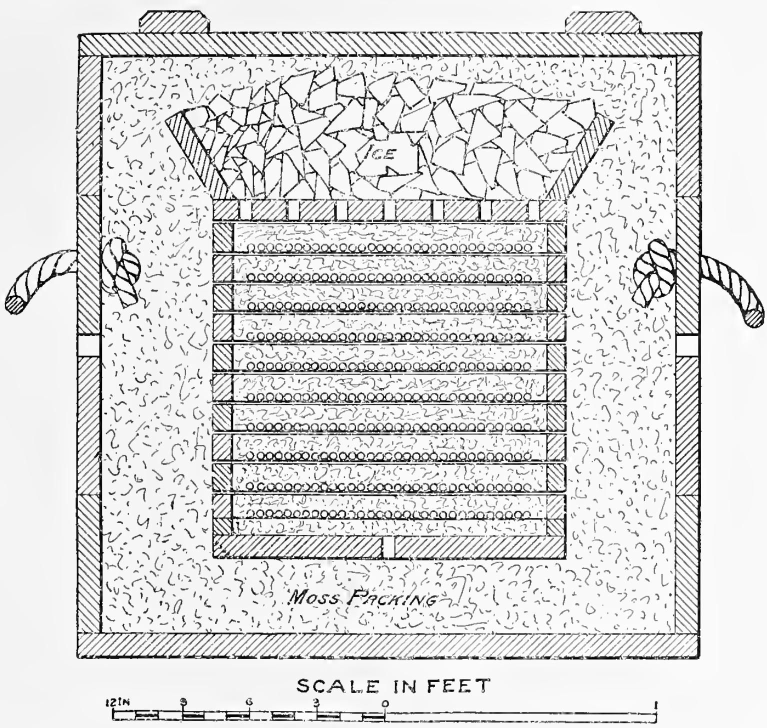


FIG. 4. Cross section through box after it has been packed and closed.

for the bottom tray. The hopper (A, plate 92) is used on the top tray. The outside case (E, plate 92) is made 7 to 8 inches larger on the sides (inside measure), and 5 inches deeper than the outside dimensions of all the crates after they are cleated together, including hopper and foundation board, as shown at D (plate 92). The trays having been thus prepared, the eggs are selected for shipment (those showing eye-spots and not too old to reach their destination before time for hatching out, making allowance for changes in temperature which they are liable to undergo on the road, causing them to hatch sooner than if left on the hatching-trays). They are taken up from the hatching-trays in pans, and after cleaning them well of all sediment, etc., and giving them a slight concussion, which can be best done by allowing water to fall on them from a

small spout or sprinkling pot, they are closely picked over, removing all dead and unfertilized eggs, which will nearly all turn white after the concussion is given.

The eyed eggs are then measured or weighed (we use apothecary scales, weigh 1 ounce and count them, or count the eggs for one tray and weigh them) and placed on the trays, the required number to each tray, and in a single layer in the middle of the tray, leaving all the empty space on the outsides next to the frame. They are then placed on the foundation board, one at a time; the eggs are covered with a piece of mosquito netting, which should be at least 2 inches larger each way than the egg trays; then the tray is filled with wet moss, the part immediately over the eggs in a loose manner, and the empty space around the eggs packed tight. This will help support the next tray above and also prevent the eggs from coming in contact with the wood and becoming dry and shriveled. After the trays are all packed and placed one upon the other, the hopper is placed on top, and the whole cleated together, as shown at D (plate 92). The crate is now ready to be placed in the box or outside case (E, plate 92). Put dry sphagnum moss, or the material to be used in packing, in the bottom of the box to the depth of 3 inches, then set in the crate of eggs, placing it as near in the center of the box as possible, pack the sides well to hold the crate in the proper position, and when the top of the hopper is reached with the packing, fill the hopper well with ice, then finish filling up the box with moss. Never use wet moss, or wet packing of any kind, for the cushion around the egg crate; it will not preserve as even a temperature and it will be liable to freeze solid if exposed to a low temperature in transit. After the box has been packed and closed, if it should be cut through the center, it would present an appearance like fig. 4, p. 251.

Amount of water necessary for incubation of eggs and rearing of the fishes.—The amount of water necessary in any case will depend upon the temperature of the water and the manner in which it is applied. The water should receive as much aeration as possible before entering the compartments containing the fish or eggs. At the Wytheville Station, where we have an even temperature of 53 degrees in the hatchery, we use in the troughs containing fish and eggs about the following quantities:

100,000 eggs during incubation, 12½ gallons per minute.
100,000 fish hatching to time of feeding, 30 gallons per minute.
100,000 fish from 1 to 4 months old, 50 gallons per minute.
100,000 fish from 4 to 6 months old, 100 gallons per minute.
100,000 fish from 6 to 12 months old, 200 gallons per minute.

These amounts are ample; less would do; probably half would suffice if it were necessary to economize in the use of water. In rearing-ponds more water is required, as the circulation is not so good and the outdoor exposure will cause the temperature to rise. If water is plentiful I would double the amounts stated above for pond-culture.

Diseases of trout fry and remedies to be applied.—The most common diseases of trout fry are the inflammation of their gills and a slimy and itching skin disease, both of which I believe are chiefly caused by impure water. The diseases may be caused by muddy water or from the foul and milky water produced in feeding the fish, especially if stale liver is used as food. The food itself may also produce it, but I think it generally comes from the fouling of the water. As an ounce of prevention is worth a pound of cure, the best plan is to prevent, if possible, the diseases by keeping the water pure. By watching the movements of the fish one can generally detect the symptoms of the diseases before they reach an alarming stage. If the

WYTHEVILLE STATION—VIEW OF TROUT-REARING PONDS, TATES RUN, AND CARP PONDS TO THE RIGHT.

gills are affected, the fish will usually swim high in the water, and in an uneasy restless manner, as if gasping for breath. When this is observed the gills should be examined to see if they are becoming inflamed and swollen. If the fish are taking a skin disease, they will generally indicate it by rubbing themselves on the bottom of the trough or against anything that may be convenient. They will dive down and give themselves a quick twisting motion against the bottom of the trough, as if they were trying to scratch a place that was itching. If the progress of the disease is not promptly checked it will soon be at a stage when nothing can be done, and the fish will grow weaker every day until they begin to die in alarming numbers.

The best remedy for both diseases that I know of is salt. Draw the water low on the fish and apply it freely by sprinkling it evenly through the water. If it is a bad case of skin disease I would use a half pint of salt for each gallon of water in the trough, or about that proportion. Watch the fish closely, and let them remain in the salt water until they get restless and begin to turn on their sides; then turn on fresh water, and as the trough fills you will have the satisfaction of seeing the slime rise and float on top of the water, like a white scum. Coarse sand should be kept in the trough for the fish to scratch themselves against. Salt will also be good for the diseased gills; it will free them of all sediment, etc., that is sure to adhere to them. Fungus, "blue swelling," etc., sometimes occur, but I have never had any serious trouble with any diseases of the fry except the two first named. Parasites will sometimes attack the fish, but if the water is pure and the fish are in a healthy condition, I hardly think the parasites will give much trouble. To keep the fish that are reared in troughs and tanks in a healthy condition, I think it is well to give them a salt bath occasionally. A little salt in their food will not hurt them, and it sometimes seems to do them good. I consider a little sediment from the reservoir, or such as collects on stones, etc., in the streams, a good preventive of disease, if mixed with their food; it is only natural that they should have something of that kind, since all, or nearly all, of their natural food contains more or less of it.

Diseases of the adult trout.—A very serious disease, for which I know no name, shows the following symptoms: The afflicted fish refuse to take food, and very dark spots, from ¼ to 1 inch in diameter, appear on different parts of the body. These spots vary in number from 2 or 3 up to 25 or 30 on each fish affected. A light spot about the size of a green pea appears on the head immediately over the brain. The fish are generally restless; some will seek the shallow water in the corners of the pond or else hide away among the plants, if there be any in the pond accessible to them. Within 24 hours from the time the disease is noticeable the fish begin to die. They will jump and dart around in the water, as if crazy, and then settle back on their tails and sink to the bottom of the pond in their last struggle for life. Almost by the time they reach the bottom they are dead and stiff. This disease made its appearance at the Wytheville Station in December, 1895. It was first observed among a lot of 637 yearling Von Behr or brown trout that had been delivered to the station on November 29 by one of the United States Fish Commission transporting cars. The first sign of this disease was noted about the 5th of December, and by the 12th of the month 455 of the 637 fish were dead. These fish being in the nursery during the first stages of the disease, the water passed from them through an empty pond into a second one containing about 1,000 large rainbow trout that had recently been stripped of their spawn. On the morning of December 23, this dreadful disease made its appearance

among the latter, and by 4 o'clock in the evening of the same day 56 of them had died. Salt was the first remedy decided upon; so the water in the pond was drawn down to about 300 gallons or probably a little more, and 150 pounds of common salt were sprinkled evenly through it. The fish were allowed to remain in this brine about 15 minutes, when they showed signs of weakening by turning on their sides; then fresh water was turned on freely. The good result was at once noticeable, the fish becoming quiet, and appearing to rest more easily. It was my intention to give them another salting two days later, but as they were steadily improving I concluded that another application was unnecessary. The final result was that 70 per cent of the adult rainbows that had been treated with salt were saved, while of the yearling brown trout, that were not thus treated, nearly 71½ per cent died.

Foul ponds are dangerous, and will produce disease if not attended to. If the fish get sick from this cause, they should be removed to a clean pond at once; give them a salt-and-clay bath, and then turn on an increased amount of fresh water for ten days or more following.

The adult fish are very liable to be affected with fungus. It generally comes after a bruise or hurt, or when the fish is in an emaciated condition. If the trouble results from an injury, it can often be cured before it spreads to the sound flesh; but if fungus spreads like a slimy web all over the fish, it is sure death. Just after spawning, they are especially susceptible to fungus. They should be handled very carefully during the spawning season to prevent the moving of a scale or scarifying the body in any way, either of which would be almost sure to be followed by fungus. If there is any hope of saving the fish, it should be treated at once, and I do not know of a better remedy than salt. Catch the fish and rub the salt on the affected part, and then release it in a pond, or tank, by itself, where it can be gotten for treatment in a day or two again. The fish that are affected all over the body should be killed and thrown out at once, as there is no chance to save them.

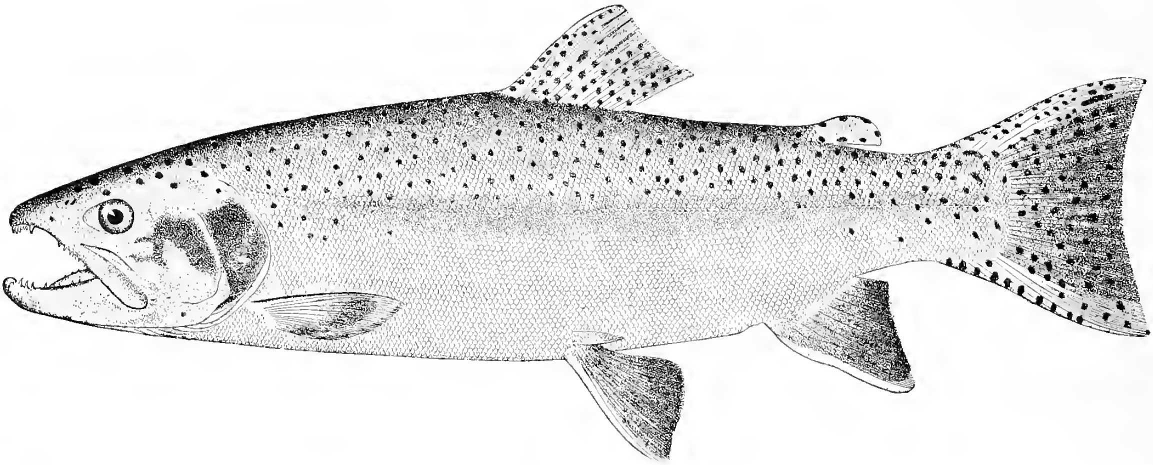
I have given in the preceding pages such practical information as I could in reference to the artificial propagation of the rainbow trout, and hope that it may prove of value to those interested in such subjects. The results that have followed our efforts in an endeavor to stock various streams in many different localities of our common country with this gamy and delicious fish, beloved alike by epicure and angler, have in most instances proved successful and have demonstrated the practicability of varying and increasing our food supply, and at the same time providing another source of amusement and recreation for all the votaries of rod and reel.

CORRESPONDENCE RELATIVE TO THE RAINBOW TROUT.

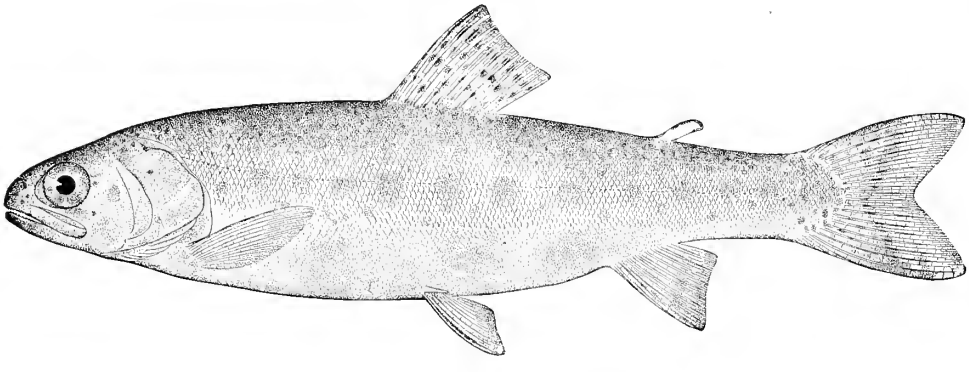
The following extracts from letters of correspondents may prove interesting as showing the experience of fish-culturists in different portions of the United States:

[From W. D. Noel, of Lebanon, Mo., April 7, 1896.]

The United States Fish Commission planted, about 12 years ago, rainbow trout in Bennett's spring, which flows into Neaugua River about a mile from the spring, making a stream from 100 to 200 feet wide and from 1 to 3 feet deep. They have increased to a wonderful extent in the spring branch, and to quite an extent in Neaugua River. They have been caught 8 miles above and 25 miles below the mouth of the branch. They are the gamest fish we have and are exceedingly shy. They take the fly here better than any bait. As for eating qualities I do not think it equaled by any fresh-water fish.



THE RAINBOW TROUT (*Salmo irideus*). Adult male.



THE RAINBOW TROUT (*Salmo irideus*). Young.

[From Livingston Stone, superintendent of United States Fish Commission Station, Baird, Cal., December 27, 1895.]

Here in the McCloud River the rainbows spawn from February to May, inclusive, and in confinement the spawning season seems to begin a month earlier than in the river. They have no average size, strictly speaking, as they are found here of sizes up to and slightly exceeding 10 pounds in weight. They are found in most mountain streams about here, and are usually quite abundant where they occur at all and have not been fished out. They rank well up as a game fish, but as a pan fish they are very much inferior to *fontinalis*, though when properly cooked they are very palatable. The temperature of the McCloud varies from about 38° at this season to 63° in July. The fly fishing is best in the spring and early summer in this part of the river.

[From M. C. Toms, Hendersonville, N. C., February 6, 1896.]

About ten years ago a small lot of young fish were placed in Green River in this county, of which nothing was known until two years afterwards, and we supposed they were lost, but after two years you could occasionally hear of one being caught. A year after this a friend of mine and myself rigged up our rods and started for this beautiful stream. We soon had our tackle in good trim and were casting our hooks far down the stream, when, to my surprise, I found that one had my hook and was making off with it. It was fine sport to reel him up the swift water, and I found it to be a 3-pounder, glowing in the sun, with his beautiful rainbow colors. No fish could look gamer. They are doing well and the river is well stocked with the little ones. If our laws were more strict we would have plenty of these beauties. Through the Fish Commissioner at Washington I have stocked several other streams, but they have not as yet had time to show what they will do. I regard the rainbow as a good biter, but not as good a puller as the brook trout.

The work of stocking these streams by the Government is a step in the right direction, and will be a great source of food and pleasure for the future. One thousand yearling fish were planted in Green River from Wytheville Station by myself on February 1, 1888.

[From J. D. Phipps, Longs Gap, Grayson Co., Va., December 30, 1895.]

I will say in reference to the fish deposited in our stream, Peach Bottom Creek, that they have grown and propagated as fast as any fish I ever saw; in fact much faster than the mountain trout. We posted the stream and allowed no fishing for four years. Now our stream is full of the finest trout. I have caught them 22 inches long. Their flavor is fine, and they are the most gamy fish I ever saw. Their rapid increase has kept the stream well supplied ever since.

[From F. N. Clark, superintendent of United States Fish Commission Station, Northville, Mich., January 23, 1896.]

The Au Sable River was first planted with rainbow trout about 17 or 18 years ago, I think, from eggs forwarded from the collecting station in California to the Michigan Fish Commission, hatched at their hatchery, and planted by them. Since that time there have been several plants made at different times, but not in large numbers. The success of this river is probably the most marked of any of the rivers of Michigan where rainbow trout have been planted. In certain portions of the river large rainbows are taken with hook and line, often weighing from 5 to 7 pounds, and in our net fishing for brook trout during October, 1895, the trout caught would run about one-third rainbow; in addition to this we would catch from 100 to 1,000 last spring's hatch, and they would run a larger number rainbow than brook trout. The rainbow caught in the Au Sable are considered by sportsmen as more gamy than either the brook trout or graylings, and it requires heavier tackle for this fish than for a brook trout of equal weight. Rainbow trout are also taken quite frequently with hook and line in Pere Marquette River, also the branches of that stream.

[From R. W. Requa, of the California State Fish Commission, Sisson, Cal., January 31, 1895.]

The waters of this State are well stocked with the different species of trout, and the fishermen all agree that the rainbow is the king of trout, its game qualities being greater than the others. The only exception to this statement is the *Salmo mykiss* of Webber Lake, Sierra County, which is noted for its game qualities. As a food-fish the rainbow is far superior to any of the trouts found in the mountain streams of this State. Those in the headwaters of streams usually have white flesh, while in those found near tide water the pink color is found. The feeding-grounds are a great factor in making up the color and flavor. Much has been said and written as to the size of the rainbow trout of California, and I find that the reports do not agree. At our spawning station on the Klamath River, in Siskiyou County, we found the average size to be as follows: First run, 5 pounds; second

run, 4 to $4\frac{1}{2}$ pounds. Very few rainbows weighing as high as 8 pounds are caught. Those from the McCloud River, a tributary to the upper Sacramento, are the finest flavored fish found on the Pacific Coast. They do not exceed 2 to 3 pounds in weight; the average would be about $1\frac{1}{2}$ to 2 pounds.

[From W. K. Hancock, foreman at United States Fish Commission Station, Leadville, Colo., January 22, 1896.]

In the streams throughout this part of the country the rainbow trout are not very plentiful, and their average size would probably be from three to five fish to the pound, but occasionally one will be taken weighing one-half to three-fourths of a pound. Their growth is very slow in our streams and small ponds in this immediate vicinity. In the lower parts of the State, south and southwest of this place, they are more plentiful, and grow much larger. In Twin Lakes, 12 miles southwest of here, they grow to 12 and 13 pounds. We have caught them 25 to 28 inches long, and weighing from 8 to 13 pounds. They are very game, and are considered fine served on the table.

[From Gustave Schnitger, State Fish Commissioner of Wyoming, October 25, 1895.]

Regarding the rainbow trout, I would say the first plant of young rainbow trout made in the Laramie River in this State was by Hon. Otto Gramm, of this commission, the eyed ova of the *Salmo irideus* being sent to him in the year 1885 by Livingston Stone, of McCloud River Station. At that time 10,000 eggs were shipped; also in 1886 there were 20,000 rainbow trout eggs sent; fry of same were planted in the Big Laramie River. Since then most of the rainbow trout raised at the hatchery, and the young trout from eggs from Neosho, Mo., are planted in Big and Little Laramie rivers and in the upper waters of North Platte River. All of these streams are excellent for these fish or, in fact, for any of the trout so far introduced. Some of the rainbow trout taken are reported as weighing as much as 9 pounds. They are truly a fine food-fish, as well as an excellent fish for anglers.

[From T. W. Scott, Rome, Ga., December 17, 1895.]

I have only fished in Raccoon Pond, the place where the rainbows were planted, two evenings since they were put there, and each evening I caught some trout; they were from 8 to 10 inches long and very game. The year after they were put there the dam broke and a great many of them escaped. I have been told by parties living near the stream, and who fish a good deal in it, that they have caught quite a number of them below in the creek, and some where the creek empties into Chattooga River. They are all about the same size, from 8 to 10 inches long. Those planted in Silver Creek are also doing nicely, from the reports from that place.

[From A. H. Gibboney, Marion, Va., July 29, 1892.]

In Holston River, where Staley Creek empties into it, this morning, Mr. Coalson, of this place, with hook and line, caught a California or rainbow trout 24 inches long and weighing $6\frac{3}{4}$ pounds. Have you ever known one to weigh so much? I get this information from Dr. Ed. Haller, who saw Mr. Venable weigh it. It was also weighed by J. E. Waldrup. It was almost ready to spawn.

[From W. T. Dennis, commissioner of fisheries of Indiana, Richmond, Ind., July 23, 1889.]

I have just returned from a visit to Tippecanoe River, at Monticello, and am happy to say that the plant of rainbow trout made there at the request of Mr. Gregory seems to have proven a gratifying success. They may be seen almost every fair evening, as the shadows creep over the water, jumping for flies and in such numbers as to prove them numerous and healthy.

[From William W. Finney, cashier of the Harford National Bank, Belair, Md., April 26, 1895.]

Several years ago I got a lot of rainbow trout from your station to stock two streams that flow into Deer Creek, a tributary of the Susquehanna River. They came in good order, and I dumped them in, and they never seemed to amount to anything. Now and then you would see an occasional trout, and then you would not see any, but the other day I was examining one of the streams and was surprised to find a good many nice-looking fellows, about 4 or 5 inches long, and here and there a big fellow. It looks like they were beginning to get a start. I was afraid the stream did not suit them and that they had cleared out.

[From J. D. Huntoon, M. D., of Lowell, Mass., November 8, 1892.]

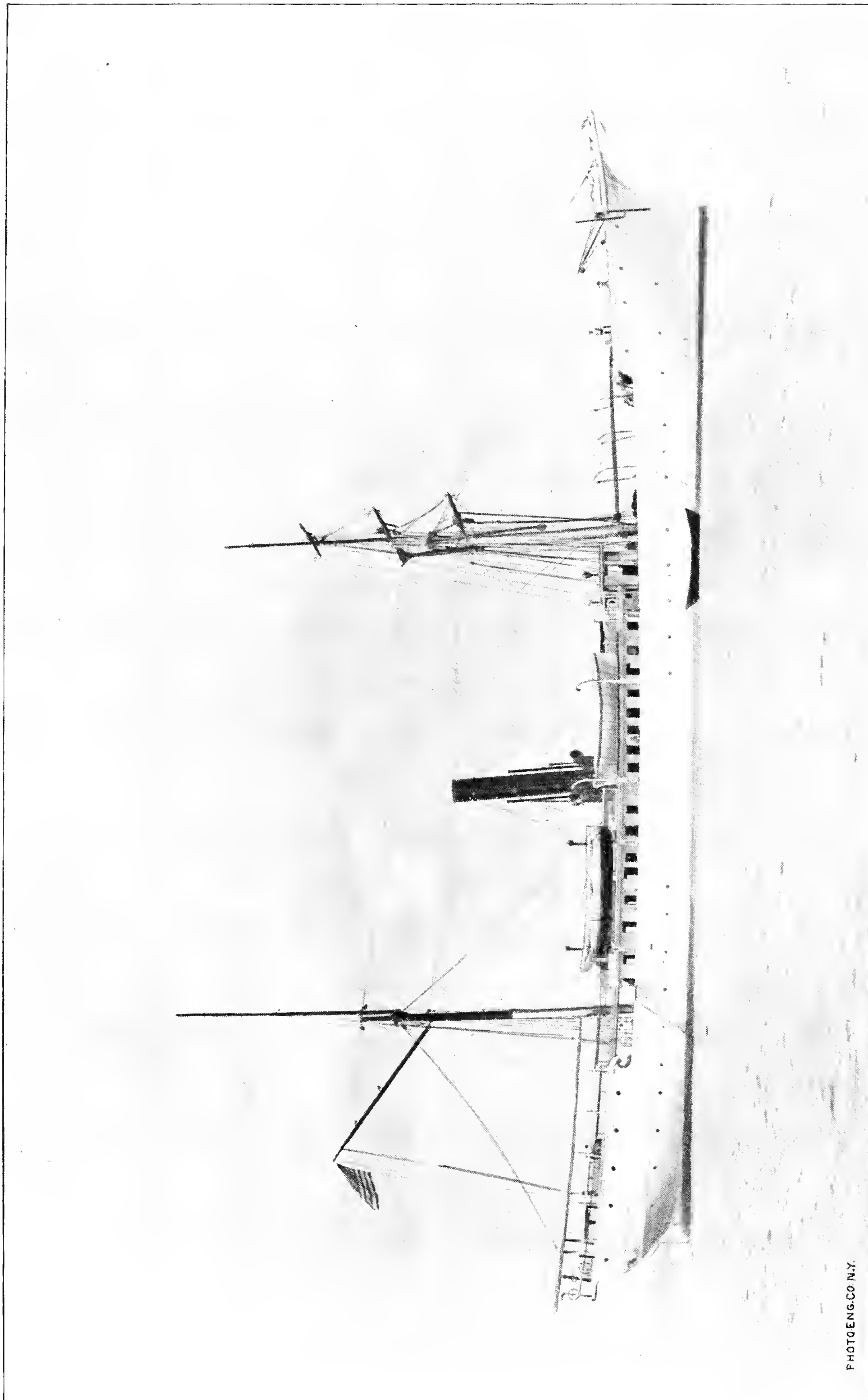
The rainbow trout sent me last season are now growing finely. I think I saved about 400 of them and put them in a spring brook, with some small ponds in its source, and have watched them closely. I hoped the larger ones would spawn this fall, but can not find any indication of it. I think them very hardy and desirable.

DEEP-SEA EXPLORATION:

A GENERAL DESCRIPTION OF THE STEAMER ALBATROSS, HER APPLIANCES AND METHODS.

By Z. L. TANNER,

Commander, United States Navy.



THE ALBATROSS.

5.—DEEP-SEA EXPLORATION: A GENERAL DESCRIPTION OF THE STEAMER ALBATROSS, HER APPLIANCES AND METHODS.

By Z. L. TANNER, *Commander, United States Navy.*

INTRODUCTION.

Early in September, 1880, immediately after the return of the U. S. Fish Commission steamer *Fish Hawk* from her initial trip off shore, to the region subsequently known as the Gulf-stream slope, Prof. S. F. Baird was impressed with the necessity of a larger vessel for deep-sea investigations. The remarkable results of the *Fish Hawk's* operations, though limited to depths of a few hundred fathoms, convinced him that his investigations should be extended into more remote and deeper waters.

In discussing the subject with the writer he remarked, in effect, that the profitable study of useful sea fishes could not be prosecuted without a knowledge of their food, the food of their food, their respective friends and foes, the habitat of the several species, and their means of passing from one region to another in the embryonic as well as the adult stage; the temperatures, currents, and specific gravity of the waters of the ocean should be studied in connection with the migratory habits of pelagic forms, hence investigations must be extended seaward wherever life exists, until a complete history of both the economical and contributory species is obtained. To prosecute these researches a sea-going steamer, specially constructed and equipped to carry on this work, was an absolute necessity.

Subsequent off-shore trips made by the *Fish Hawk* further convinced him of the importance of having a larger ship. The subject was frequently under discussion, and a few months later he requested the writer to make general plans and estimates for the construction and equipment of a thoroughly seaworthy steamer, capable of making extended cruises and working with dredge and trawl in all depths to 3,000 fathoms.

A rough plan was accordingly prepared, showing the type of vessel contemplated, and distribution of weights and spaces, from which the final designs were made by the late Charles W. Copeland, an eminent marine architect and engineer, of New York. After the usual competitive bids required for Government work, the contract was awarded to the Pusey & Jones Company, of Wilmington, Del., in March, 1882, for the sum of $145,800, exclusive of outfit and special equipment, which cost an additional $45,000. She was launched August 19, 1882, was christened the *Albatross*, and went into commission on the 11th of the following November.

The writer was ordered to superintend her construction in addition to his duties as commanding officer of the *Fish Hawk*. Passed Assistant Engineer George W. Baird, United States Navy, superintended the construction of machinery and also had general supervision of all work in the absence of the writer. He rendered efficient service in devising and perfecting many novel mechanical appliances with which the

vessel was provided, and was subsequently ordered as chief engineer, his cruise extending over the unusual period of five years.

The writer assumed command November 11, 1882, and was detached May 1, 1894, having made a continuous cruise of eleven and a half years.

This publication is essentially a revision and extension of the "Report on the construction and outfit of the U. S. Fish Commission steamer *Albatross*, 1883," and was undertaken at the instance of the late Commissioner, Marshall McDonald, who was desirous that the experience of the writer in deep-sea exploration, extending over a period of fifteen years, should be made available in a convenient form. It comprises an account of the important changes in appliances and improvement in methods, treating the several branches in detail, with a view of furnishing to the beginner such information as would have been most valuable to the writer when he first took up the work.

Brief historical sketches are given of the development of physical and biological researches during the last half century leading up through the evolutionary stages to the present time, and finally illustrating the modern science of deep-sea investigation as practiced on board the *Albatross*.

A change in the arrangement of fire-room and coal bunkers followed the installation of new boilers of a different type from those originally in the vessel; the ventilating apparatus has been much improved; ingeniously constructed counter balances have been applied to the main engines; and the maneuvering qualities of the vessel are much improved by the introduction of pneumatic annunciators which enable the officer on the bridge to observe the movements of the engines by reference to a conveniently placed dial and pointer. The old cast-iron propellers have been replaced by new ones of bronze, having finer pitch and less weight; a Baird evaporator greatly improves the quality of water distilled for drinking purposes and furnishes fresh feed for the boilers.

The changes and additions to the scientific apparatus will be described in detail.

Acknowledgments are made to the following authorities, who have been freely quoted:

Sir C. Wyville Thomson, "Depths of the Sea" and "The Voyage of the *Challenger*."

Rear-Admiral G. E. Belknap, United States Navy, "Hamersley's Naval Encyclopedia" and "Deep-Sea Soundings in the North Pacific."

Commander C. D. Sigsbee, United States Navy, "Deep-Sea Sounding and Dredging."

Lieut. Commander Seaton Schroeder, United States Navy, and Chief Engineer George W. Baird, United States Navy, "Report on the Construction and Equipment of the U. S. Fish Commission steamer *Albatross*."

The late J. H. Kidder, M. D., "Report on the thermometers of the United States Commission of Fish and Fisheries."

Mr. O. H. Tittmann, "United States Coast and Geodetic Survey Bulletin, No. 18."

The writer would also express his indebtedness to Dr. John Murray, of Edinburgh, Scotland, for a specially prepared paper on the methods of recognizing marine deposits, and to Prof. C. F. Marvin, United States Weather Bureau, for a paper on the method of correcting thermometers.

Special thanks are tendered to Mr. James E. Benedict, the first resident naturalist of the *Albatross*, and to Mr. C. H. Townsend, who succeeded Mr. Benedict after a short interval, and still holds that responsible position, for data kindly furnished for the chapter on the preparation and preservation of specimens.

Bull. U. S. F. C. 1896. (To face page 261.)

PLATE II.

FIG. 1. PLAN OF POOP, HOUSE & FORECASTLE DECKS

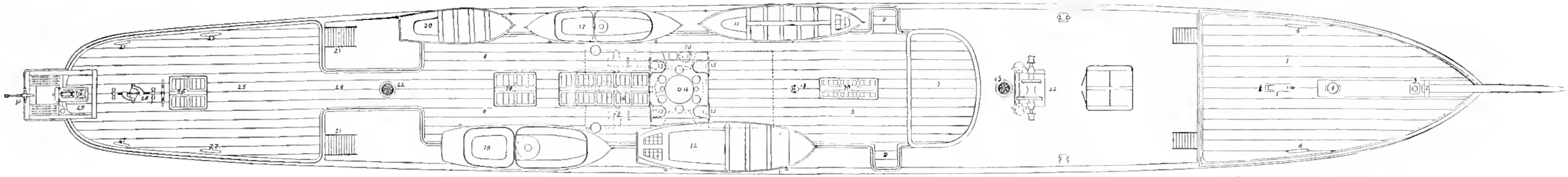


FIG. 2. PLAN OF MAIN DECK

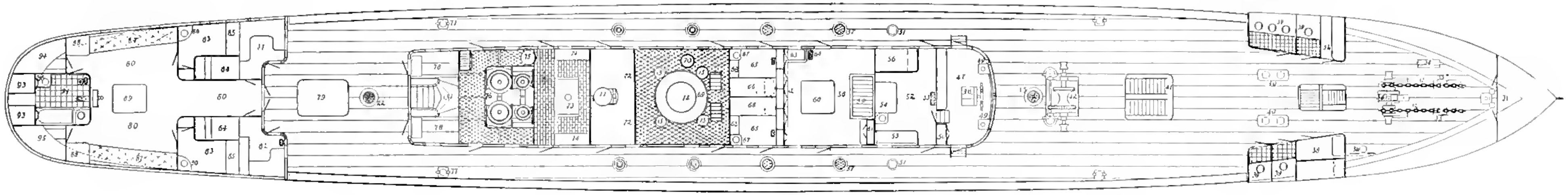


FIG. 3. PLAN OF BERTH DECK

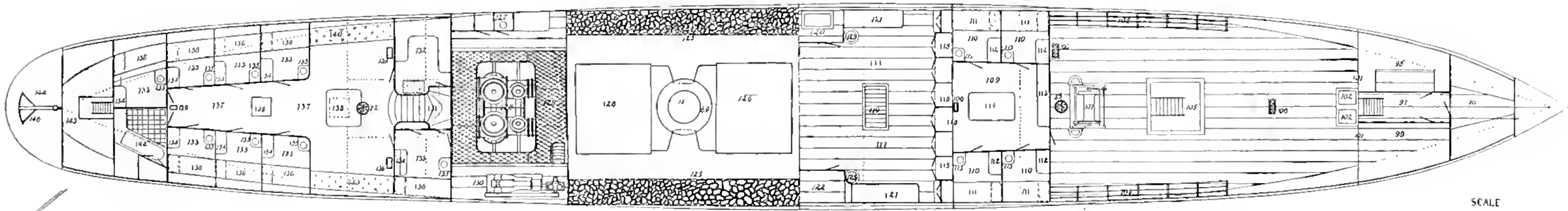
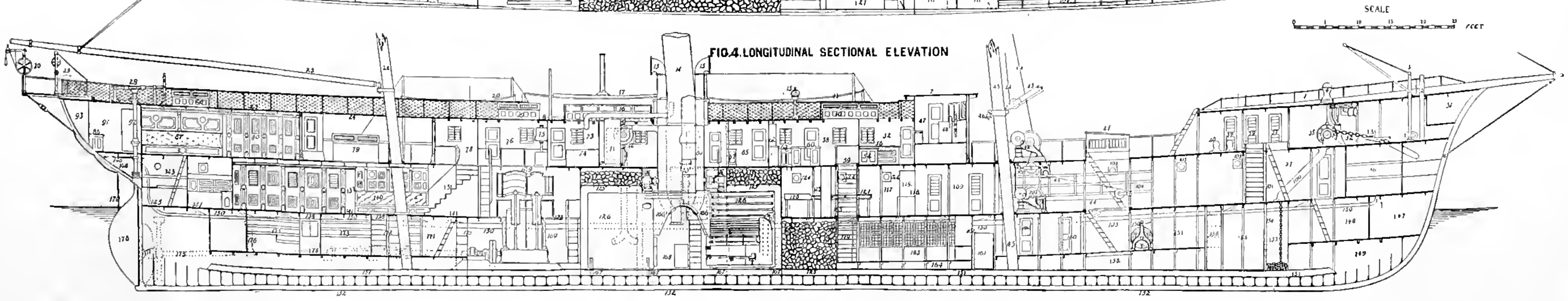


FIG. 4. LONGITUDINAL SECTIONAL ELEVATION



PLAN OF THE ALBATROSS.

Poop, house, and forecastle decks.

1. Forecastle.
2. Wooden bitts.
3. Fish davit.
4. Steam capstan.
5. Hotchkiss revolving cannon.
6. Iron cleats.
7. Top of pilot-house.
8. Top of deck-house.
9. Bridge.
10. Skylight over chart-room and laboratory.
11. Whaleboat.
12. Ten-oared cutter.
13. Standard compass.
14. Smokestack.
15. Ventilators to fire-room.
16. Skylight over drum-room and galley.
17. Steam gig (Herreshoff).
18. Steam cutter (Herreshoff).
19. Engine-room skylight.
20. Dingey.
21. Poop ladders.
22. Mainmast.
23. Mainboom.
24. Bridge from poop to deck house.
25. Poop deck.
26. Cabin skylight.
27. Iron bitts.
28. Auxiliary steering gear.
29. Sigsbee deep-sea sounding-machine.
30. Tanner sounding-machine.

Main deck.

31. Paint locker.
32. Chain cables.
33. Stopper for chain cables.
34. Compressor for steel-wire hawser.
35. Steam windlass.
36. Forecastle pump.
37. Lamp-room.
38. State-room for petty officers.
39. Water-closets.
40. Iron bitts.
41. Fore hatch.
42. Dredging engine.
43. Dredging boom.
44. Dredge rope, rove for use.
45. Foremast.
46. Ship's bell.
47. Pilot-house.
48. Steering gear, hand and steam.
49. Binnacle.
50. Signal locker.
51. Deck lights.
52. Chart-room.
53. Steam heater.
54. Chart table.
55. Chronometer box and lounge.
56. Berth.
57. Bunker plate and coal-chute.
58. Upper laboratory.
59. Hatch to lower (or main) laboratory.
60. Work table for naturalists.
61. Chemical case for preservative mixtures.
62. Bookcase; scientific library.
63. Sink.
64. Steam heater.
65. Naturalist's state-rooms.
66. Berth.
67. Washstand.
68. Bureau.
69. Steam drum.
70. Ash-chute.
71. Baird's evaporator.
72. Exhaust fans for ventilating the vessel.
73. Galley.
74. Sink.
75. Baird's distiller.
76. Upper engine-room.
77. Iron bitts.
78. Ward-room companion-way.
79. Ward-room skylight.
80. Commanding officer's cabin.
81. Cabin pantry.
82. Commanding officer's office.
83. State-room.
84. Berth.
85. Bureau.
86. Washstand.
87. Lounge.
88. Sideboard.
89. Table.
90. Steam heater.
91. Bath-room.
92. Rudder head.
93. Water tank.
94. China closet.
95. Linen closet.

Berth deck.

96. Yeoman's store-room.
97. Fore passage.
98. Dredging store-room.
99. Brig.
100. Chain pipes leading to lockers.
101. Collision bulkhead.
102. Hatch to ice box.
103. Air port.
104. Bag rack.
105. Hatch to main hold.
106. Steam heater.
107. Reeling engine.
108. Governor.
109. Steerage.
110. Steerage state-rooms.
111. Berth.
112. Bureau.
113. Washstand.
114. Table.
115. Open pantry.
116. Water-tight iron bulkhead.
117. Lower (or main) laboratory.
118. Lockers with movable trays for specimens.
119. Ladder to laboratory store-room.
120. Photographer's dark room.
121. Table.
122. Dispensary.
123. Coal-chute.
124. Air ports.
125. Coal-bunkers.
126. Boilers.
127. Oil-tanks.
128. Iron floor grating.
129. Main engines.
130. Dynamo and engine (Edison system).
131. Ward-room companion stairs.
132. Ward-room pantry.
133. State-room.
134. Bureau.
135. Washstand.
136. Berth.
137. Ward-room.
138. Table and water-tight doors.
139. Steam heater.
140. Lounge.
141. Iron water-tight deck.
142. Bath-room.
143. Cabin store-room.
144. Quadrant-room.
145. Ventilating pipe.
146. Quadrant of rudder.

Holds.

147. Magazine.
148. Magazine passage.
149. Fore peak.
150. Ventilating pipe with branches.
151. Keelson.
152. Keel.
153. Chain lockers.
154. Collision bulkhead.
155. Ice box.
156. Cold-room.
157. Main hold.
158. Lower hold.
159. Steel-wire hawser and reel.
160. Store-room.
161. Fresh-water tanks.
162. Water-tight iron bulkhead.
163. Laboratory store-room.
164. Ballast and sinkers.
165. Water-tight iron bulkhead.
166. Uptake.
167. Boiler leg.
168. Fire-room.
169. Lower engine-room.
170. Water-tight iron bulkhead.
171. Ward-room, store-room, and shaft alleys.
172. Water-tight iron bulkhead.
173. Paymaster's store-room.
174. Equipment and navigation store-room.
175. Propeller shaft.
176. A-frame for propeller shaft.
177. Propeller.
178. Rudder.
179. Rudder chains.

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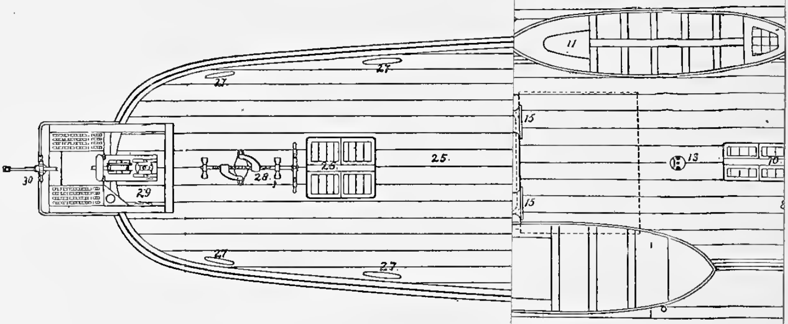
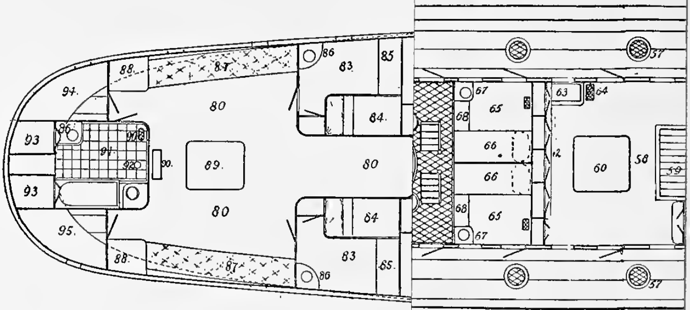
OP, HOUSE & FORECASTLE DE



. PLAN OF MAIN DECK



. PLAN OF BERTH DECK

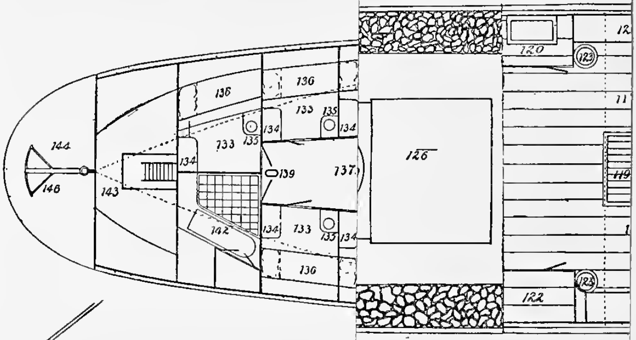
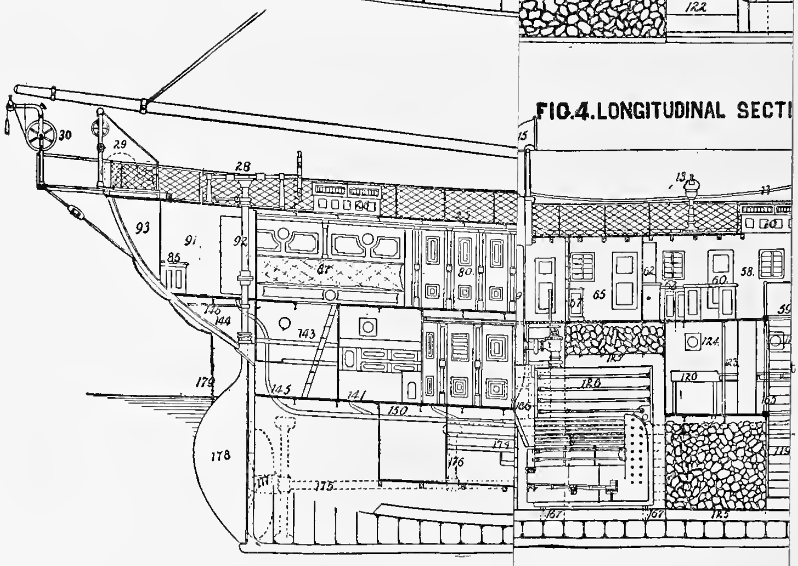


FIG.4. LONGITUDINAL SECTI



THE ALBATROSS: HER DIMENSIONS, GENERAL DESIGN, AND METHOD OF CONSTRUCTION.

The *Albatross* is an iron twin-screw steamer constructed in accordance with Lloyd's rules for vessels of her class, except where extra strength and protection were given her in view of the severe strains and unusual exposure to which she would be subjected in the prosecution of her special work. She was built by the Pusey & Jones Company, of Wilmington, Del., launched August 19, 1882, and went into commission on the 11th of the following November.

Her general dimensions are as follows:

Length over all, 234 feet.
Length at 12-foot water-line, 200 feet.
Breadth of beam, molded, 27 feet 6 inches.
Depth from top of floor to top of deck beams, 16 feet 9 inches.
Sheer forward, 5 feet 2 inches.
Sheer aft, 3 feet.
Height of deck house amidships, 7 feet 3 inches.
Displacement on 12-foot water-line, 1,074 tons.
Registered tonnage (net), 384 tons.

She is rigged as a brigantine, carrying sail to a foretop-gallant sail. The spars are white pine and spruce.

Spars.			Sails.		
Name.	Feet.	Diameter in inches.	Name.	Canvas.	Square feet.
Mainmast above main deck	56	20	Mainsail	No. 2	1,488
Maintop-mast above cap	32	$9\frac{1}{2}$	Gaff-topsail	No. 7	578
Foremast above deck	52	21	Foresail (27-foot drop)	No. 2	1,156
Foretop-mast above cap	30	$10\frac{1}{2}$	Fore trysail	No. 2	872
Fore yard, length	50	11	Foretop-sail ($24\frac{3}{4}$-foot hoist)	No. 4	934
Foretop-sail yard, length	40	9	Foretop-gallant sail ($14\frac{1}{4}$-foot hoist)	No. 6	389
Foretop-gallant yard, length	$27\frac{1}{2}$	$5\frac{1}{2}$	Fore staysail	No. 2	660
Fore gaff	27	$7\frac{1}{2}$	Jib	No. 5	918
Main boom	56	$12\frac{1}{2}$	Flying jib	No. 6	526
Main gaff	36	$9\frac{1}{2}$			
Dredging boom	36	10	Total sail area		7,521

Bowsprit, 13 inches square, 10 feet outboard to shoulder. Round-top on foremast. Cross-trees on mainmast.

Anchors and chains: One 1,900 pounds, 120 fathoms, $1\frac{3}{8}$-inch chain; one 1,288 pounds, 120 fathoms, $1\frac{3}{16}$-inch chain; one 1,030 pounds; one 600 pounds; 250 fathoms Bullivant's elastic steel wire cable, $3\frac{1}{2}$ inches circumference.

DETAILS OF CONSTRUCTION.

Hull: The *Albatross* has a "bar" keel of the best hammered iron, 8 by $2\frac{1}{4}$ inches, scarfs 25 inches in length. There is one bilge keel on each side, $10\frac{1}{4}$ feet from center line, parallel thereto, of two angle-irons 4 by 6 by $\frac{5}{8}$ inches, with a $\frac{7}{8}$-inch iron plate, 16 inches deep, riveted between, 80 feet in length, tapering in depth to nothing at each end.

The stern-post is of the best hammered iron, $7\frac{1}{2}$ by $2\frac{1}{2}$ inches; and the stem is of the same material, $7\frac{1}{2}$ by $2\frac{1}{4}$ inches. The frames are of angle-iron; those under the engines and boilers 4 by 3 by $\frac{7}{16}$ inches; forward and aft of these they are $3\frac{1}{2}$ by 3 by $\frac{7}{16}$ inches. Frames and floor spaces, 21-inch centers.

The floors are in one piece, 18 inches deep and $\frac{8}{16}$ inch thick for three-fifths the vessel's length amidships, $\frac{7}{16}$ inch thick forward and aft. They are on every frame extending 20 inches above top of floor amidships, molding to size of frames.

One limber-hole is cut on each side of the center keelson. Enlarged floors with necessary angle-irons and strengthening plates are provided for the foundations of the engines and boilers.

Reverse bars: The reverse bars are of angle-iron, 3 by 3 by $\frac{6}{16}$ inches, one on every frame extending to the stringer plate and 12 inches above the upper turn of the bilge alternately. There are double reverse bars on all frames under the engines and boilers, and also on the line of all keelsons, hold stringers, and bulkheads. Joints are covered with angle-iron butt-straps, not less than 18 inches long, with three rivets in each end.

Keelsons: On top of the reverse bars there is a center keelson, 12 by $4\frac{1}{2}$ inches, beam iron, $\frac{5}{8}$ inch thick for three-fifths the length amidships, and $\frac{4}{8}$ inch thick forward and aft. On each side, 8 feet 8 inches from the center line, there is a keelson of two channel bars, $7\frac{1}{2}$ by $2\frac{1}{2}$ by $\frac{5}{16}$ inches, riveted back to back; and at the bilge on each side a keelson of two angle-irons, 6 by $3\frac{1}{2}$ by $\frac{7}{16}$ inches, riveted back to back. The bilge keelsons conform to the shape of the floors, and the side keelsons run parallel to the center line. There is also a cross keelson for the shaft stuffing-boxes. At a distance of 4 feet 7 inches from the center line on each side there runs a keelson of beam iron, 8 by $4\frac{1}{2}$ by $\frac{5}{8}$ inches, riveted to the reverse bars.

Intercostal keelsons: Of these there is one of $\frac{6}{16}$-inch plate run on the center line, and one of $\frac{5}{16}$-inch plate under each side keelson, extending from keel to top of floors, well fitted between floors, and connected with them by an angle-iron $2\frac{1}{2}$ by $2\frac{1}{2}$ by $6\frac{6}{16}$ inches. Additional intercostal keelsons are placed under the engines.

Deck beams: For the main deck they are of T bulb-iron, on alternate frames, 7 by $3\frac{3}{4}$ by $\frac{7}{16}$ inches for three-fifths the vessel's length amidships; forward and aft they are 6 by $3\frac{3}{4}$ by $\frac{3}{8}$ inches, except at the capstan and riding-bitts forward and at hatches, where they are 8 by $\frac{7}{16}$ inches.

Stringers: The main-deck stringers on each side are 38 inches wide by $\frac{1}{2}$ inch in thickness at midlength, reduced to 26 inches width at the end. Stringers are connected with sheer-strake by angle-irons, $4\frac{1}{2}$ by $3\frac{1}{2}$ by $\frac{7}{16}$ inches, securely riveted to both the deck beams and sheer-strake. At the foremast and mainmast there is riveted to the deck beams a stringer plate 42 inches wide and $\frac{3}{8}$ inch thick, long enough to cover two beams forward and aft of the mast, securely riveted to the deck beams; through this plate a hole for the mast is cut. Similar tie-plates, covering three or four beams, are riveted in wake of bitts, windlass, capstan, hoisting engine, and reeling engine.

Ties of main deck are run fore and aft from end to end each side of center line, at such distance from it as to clear all hatches. They are of plate iron, 15 by $\frac{1}{2}$ inches, securely riveted to deck beams and to stringer plates or breast hooks at the end; butts closely fitted and butt-straps double riveted. The width of these plates is gradually reduced to 9 inches forward and aft.

Hold stringers are 24 inches wide by $\frac{1}{2}$ inch thick at midlength, gradually reduced to 18 inches in width at the ends, and are run fore and aft on frames at a height of 10 feet above top of floors, connected to deck beams and reverse bars by angle-irons. Alongside of the engines and boilers, where there are no hold-beams, these angle-irons are doubled back to back and riveted through.

Beams of berth deck: Forward and aft of engines and boilers, and between them, there are hold-beams of channel-iron, 6 by $2\frac{1}{8}$ by $\frac{3}{8}$ inches, spaced to every alternate frame, connected and riveted to hold stringers and frames, and kneed to frames the same as the main-deck beams.

THE CABIN.

Bulkheads: One collision water-tight bulkhead about 25 feet from the stem; one at the after end of the forehold, connected by deck plates as shown on the plan; one forward of boilers, connected by iron deck; one between the engines and boilers; a water-tight compartment abaft the engines between the shafts, the after end extending to the after collision bulkhead, which is at the forward end of the stern pipes; it is attached to the cross keelson which sustains the stern pipes, and extends to the berth deck with a plate-iron covering over the beams so as to make the after compartment entirely water-tight; the other bulkheads extend from the floors to the main-deck beams. Bulkheads are of $\frac{5}{16}$ iron butt-joints; strakes run in one length from floors to deck beams, 30 inches wide. The lap strips of joints are of T iron, $3\frac{1}{2}$ by 3 by $\frac{5}{16}$ inches; laps single-riveted with $\frac{5}{8}$ rivets. The after collision bulkhead has recently been extended up to the main deck. Sluice valves are provided; bilge suction-pipes from the several compartments connect to a manifold in the engine compartment, and each pipe has a foot valve.

Iron deck-house: The sides of the midship deck-house from the after end of the house to the bulkhead forward of the funnel, including these two bulkheads, are of plate iron, No. 5 wire gauge; stanchions, of 3 by 3 inches, angle-iron, spaced 24 inches from center to center. The beams are of angle-iron, 3 by 3 by $\frac{5}{16}$ inches, riveted to stanchion and to stringer and hatch-plate below.

Plating: The plating is run in fair lines, in and out strakes; all horizontal seams are lapped and all vertical seams, including bulwarks, are butted; spaces between outer strakes and frames are filled with liners of proper width and thickness.

The garboard-strake is $\frac{10}{16}$ inch thick for three-fifths its length amidships, gradually reduced to $\frac{8}{16}$ inch at the ends, and is 32 inches wide.

Sheer-strakes are fayed next to frames, $\frac{10}{16}$ inch thick for one-half the length amidships, gradually reduced to $\frac{8}{16}$ inch at the ends, and 38 inches wide. The upper edge extends $3\frac{1}{2}$ inches above top of plank-sheer to connect bulwark plates.

Bulwark plates from sheer-strake to rail are $\frac{5}{16}$ inch thick, well riveted to sheer-strake and frames. Along the whole length of the upper edge of the bulwark plates, on the outside, is run an angle-iron, $3\frac{1}{2}$ by $3\frac{1}{2}$ by $\frac{3}{8}$ inches, well riveted to bulwark plates, with proper lap-strips at the butts. To this angle-iron the rail is fastened.

The side-strake next below the sheer-strake is $\frac{4}{8}$ inch thick at midship length, gradually reduced to $\frac{7}{16}$ inch forward and aft. The remaining side plating is $\frac{6}{16}$ inch thick, except the strakes around the shaft-pipe, which are of $\frac{7}{16}$ inch and are doubled, and the bilge-strake, which is $\frac{9}{16}$ inch thick for two-thirds the length amidships, gradually reduced forward and aft to $\frac{7}{16}$ inch.

The bottom between bilge and garboard strakes is $\frac{4}{8}$ inch thick for three-fifths the length amidships, then gradually reduced to $\frac{7}{16}$ inch forward and aft.

All butts of plating, keelsons, and stringers are double chain riveted, and the longitudinal seams lapped and single riveted. All plates are long enough to cover at least six frame spaces, except short plates at the ends; and there are at least two strakes between butts falling between same frames. All edges and butts are planed.

Butts of garboard strakes are at least two frame spaces apart, as also are those of sheer strakes and deck stringers. All butts of plating are properly shifted.

Rail: The rail is of white oak, $10\frac{1}{2}$ by $3\frac{1}{2}$ inches, let down to a fair bearing on the bulwark angle-iron, hook-scarfed and edge-bolted through scarfs.

MAIN DECK (PLATE II).

Cabin (plate III): Of the structures which rise above the main rail the poop cabin extends 30 feet forward from the stern-post, is the whole width of the vessel, and 7 feet 3 inches high from deck to deck. It contains two state-rooms, an office, pantry, and bath-room, besides lockers, etc., and is supplied with light and air from eleven air-ports (five on each side and one in the stern), two windows, and three doors opening forward, and one skylight 6 by 5 feet overhead.

Deck-house: Forward of the cabin there is a clear space of 16 feet containing the ward-room skylight, and from which the gangway ladders lead over the side. Next comes the deck-house, 83 feet in length, 13 feet 6 inches in width, and 7 feet 3 inches in height. It is built of iron from the funnel aft, sheathed inside and out with wood, and fitted with iron storm-doors. From the funnel forward it is of wood, all fastenings, nails, screws, etc., being of galvanized iron. Beginning aft, it is divided into the following apartments:

(1) Entrance to ward-room: Six feet in length and the whole width of the house. One window on each side furnishes light and air, and two doors opening aft give access to the stairway leading to the ward-room below.

(2) Upper engine-room: This is 10 feet 6 inches in length and the full width of the house. It has one door and one window on each side, a skylight 5 by 5 feet overhead, and a stairway leading to the engine-room below. The inside wooden doors of this room, as well as those of the kitchen and drum-room next forward, are fitted in halves, upper and lower, so that in bad weather the lower halves may be closed to keep out the water, while the upper are open for ventilation.

(3) Kitchen: In length 8 feet, the whole width of the house, with one door and one window on each side, and a skylight 4 by 5 feet overhead. It is furnished with a table, fuel-boxes, lockers, dish-racks, and a lead-lined sink fitted with a pump, drawing water from the tanks in the hold.

(4) Drum-room: This is also the entrance to the fire-room, is 20 feet in length, and the width of the house. It is fitted with doors and windows like those of the engine-room, has a skylight 5 by 10 feet overhead, and communicates by a stairway with the fire-room below. As its name implies, this room contains the steam drum, which is so designed that the funnel passes up through it, thus utilizing the heat of the escaping products of combustion to superheat the steam. It also contains the ventilating apparatus and Baird evaporator.

(5) State-rooms: Forward of the drum-room the wooden part of the deck-house commences with two state-rooms, one on each side, for the members of the scientific corps. Each room is 6 feet 6 inches in length, half the width of the house, and has a door and window with blind shutters, a berth 30 inches in width, a writing-desk, washstand, drawers, lockers, etc. Additional ventilation is secured by lattice-work openings, outboard, and also between the rooms.

(6) Upper laboratory (plate IV): This is 14 feet in length and the whole width of the house. It is supplied with light and air by two windows and a door on each side and a skylight 6 by 3 feet overhead. In the center is a conveniently arranged work table, square in shape, around which four persons can seat themselves, each having at his right hand a tier of drawers which form the legs of the table. There are also two hinged side tables, a sink with alcohol and water tanks attached, wall cases for books and apparatus, and in one corner a chemical case.

UPPER LABORATORY.

PLATE V.

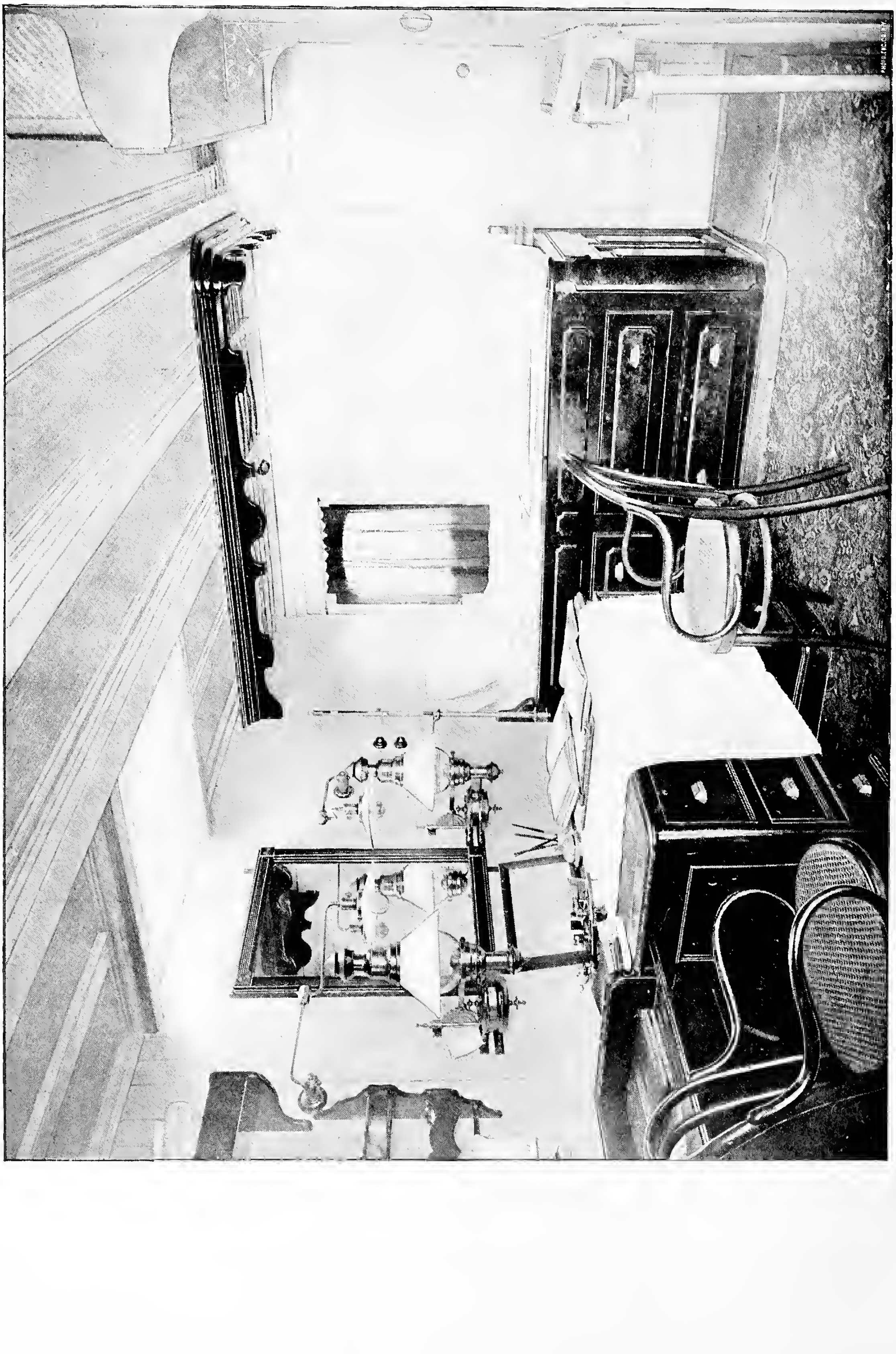
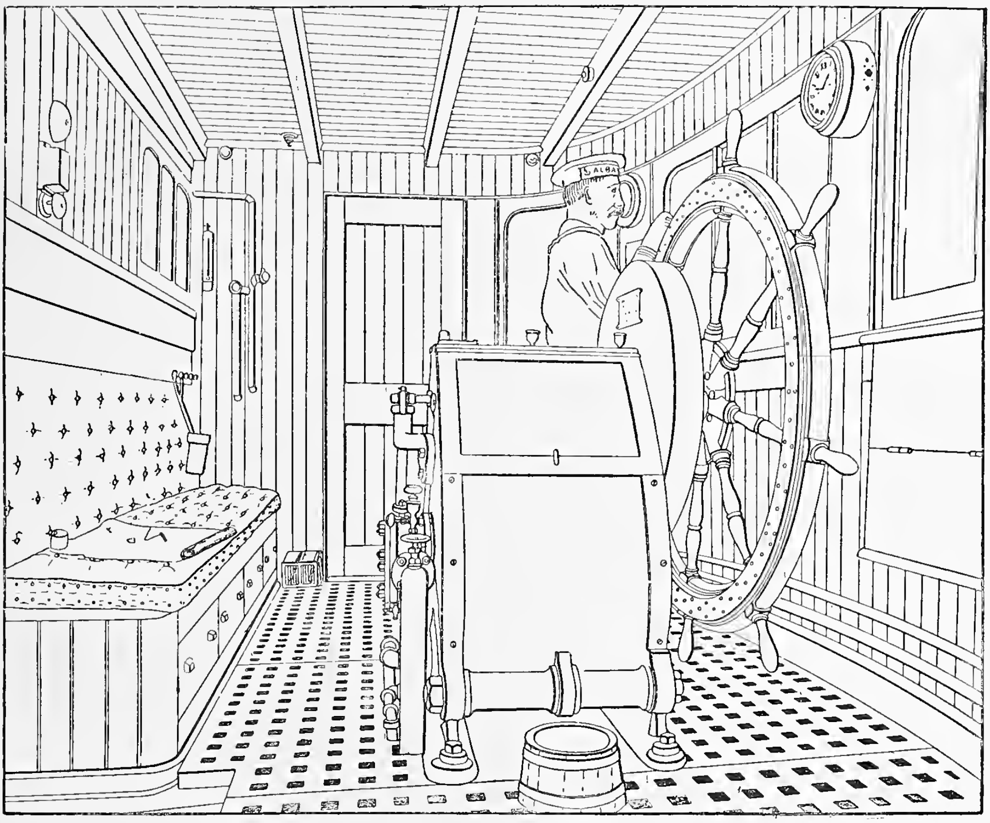


CHART ROOM.

(7) Chart-room (plate V): Immediately forward of the laboratory is the chart-room, 8 feet 6 inches in length, the full width of the house. It has one door and window on each side and a skylight 3 by 3 feet above, drawers for charts, etc., a berth, washstand, lockers, bookshelves, and a transom sofa, which is also used as a chronometer chest. A door in the forward bulkhead gives access to the pilot-house.

(8) Pilot-house: This is the next and last division of the deck-house. It is 8 feet in length, the full width of the house, and has one door on each side. The front is elliptical, with glass windows balanced by weights, and protected in bad weather by strong wooden shutters hung in the same manner as the windows and fitted with 8-inch bull's-eyes in the center.



CUT 1.—Interior of pilot-house, steam steering engine.

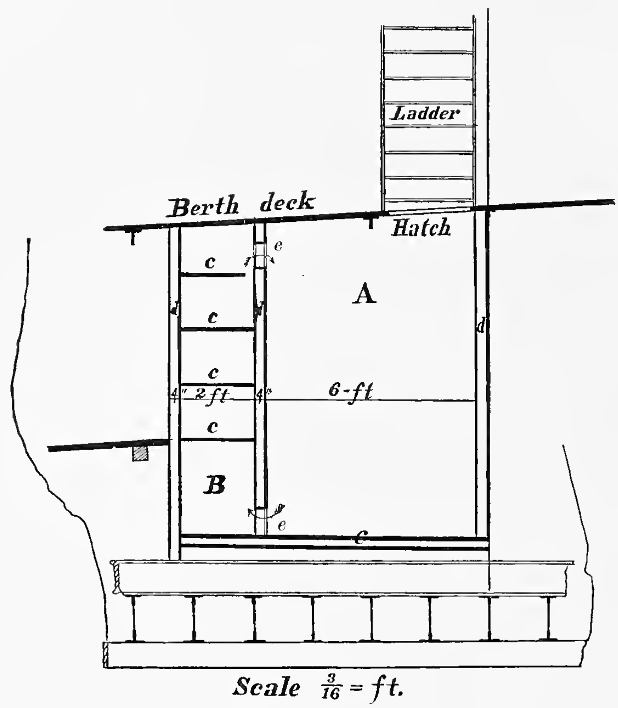
The pilot-house is raised about 3 feet above the main deck and projects the same distance above the top of the house, with which it communicates by two windows. Suitable bell pulls and speaking tubes furnish the necessary means of communication with the engine-room, and instead of the ordinary ship's wheel a Higginson's steam quartermaster is used.

Topgallant forecastle: The topgallant forecastle is 44 feet in length and 6 feet 3 inches in height between decks. On it are stowed the anchors, which are handled by a single fish-davit amidships and a capstan which can be worked by hand or by the steam windlass directly underneath, and just abaft the capstan is a 37 mm. Hotchkiss revolving cannon, mounted on a tripod.

Underneath the forecastle are water-closets for officers and men, petty officers' room, lamp-room, paint locker, steam windlass, and carpenter's bench. Two scuttles give access, one to the store-rooms, magazine, etc., forward of the collision bulkhead, and the other to the berth deck.

Berth deck: This includes the space 40 feet aft from the collision bulkhead, and is 7 feet 10 inches between decks. It is supplied with light and air by the fore hatch, fore scuttle, and by eight 8-inch air ports, four on each side. Racks for stowing bags and hammocks are fitted along the sides; the space abaft the fore hatch is occupied by the reeling engine, and near the forward bulkhead are two scuttles opening into the ice boxes.

Ice-boxes: These occupy the space in the hold 7 feet aft from the collision bulkhead, the whole width of the ship. A strong fore and aft bulkhead amidships divides this space into two compartments; the sides and ends are fitted double with an intervening air space of 4 inches, which is filled with proper nonconducting material. The inside is lined throughout with galvanized iron, and, at the after outboard corners, lead pipes with suitable traps drain the water into the bilge. The capacity of the ice boxes is about 3 tons each, 6 tons in all.



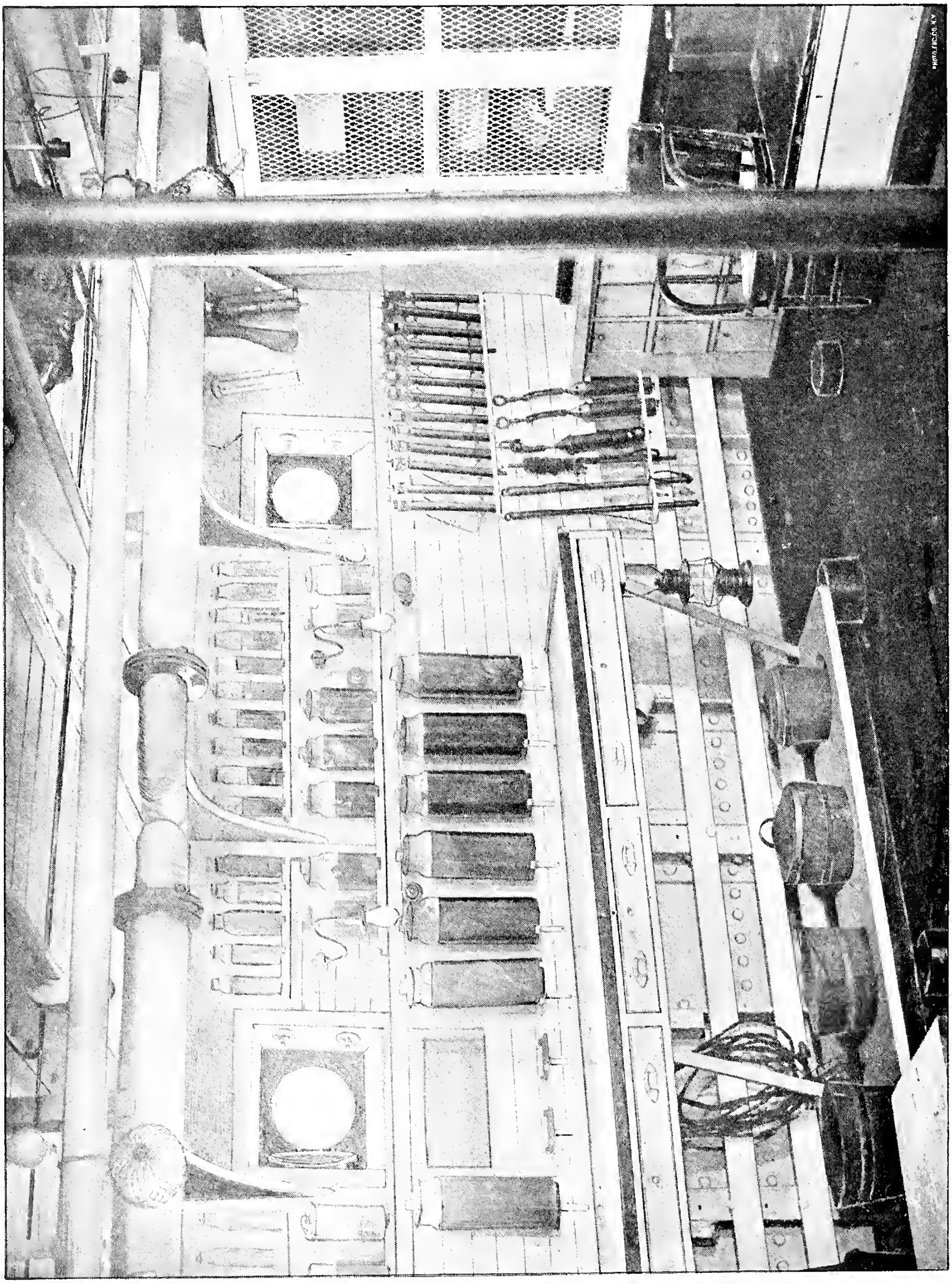
CUT 2.—Ice-boxes and cold-room.

Cold-room: The after part of the spaces in the ice-boxes A for 2 feet is partitioned off by an athwartship bulkhead to form the cold-rooms or refrigerators B, to which access is gained by doors which open into the forehold. Six-inch openings *e*, at the top and bottom of the cold-rooms, communicate with the ice-lockers A, and a circulation of air is induced as the warmer air of the former rising passes above into the latter, becomes cooled by the ice, falls and reenters the cold-rooms by the lower openings, to become warmer again and rise as before. Rack shelves *c* to hold whatever is desired are fitted against the bulkheads *d*.

Store-rooms, magazine, brig, etc.: Forward of the berth-deck, and separated from it by the collision bulkhead, is a fore-and-aft passageway to which access is gained by a scuttle and stairs underneath the top-gallant forecastle.

This passage opens forward into the yeoman's store-room, to the right into the brig, lighted and ventilated by an 8-inch air-port, and to the left into the dredging store-room, similarly furnished with light and air.

Through this passage, also, the chain pipes pass down and aft, taking the chain from the windlass to the lockers below, and from the forward end of the passage a



LOWER LABORATORY, PORT SIDE.

LOWER LABORATORY, STARBOARD SIDE.

scuttle and stairs lead down to the magazine passage and magazine, and to the fore-peak below them.

Mainhold: Below the berth-deck the space from the cold-room aft is taken up by the mainhold, steerage store-room, engineer's store-room, bread-room, sail-room, and water-tanks. Access is gained by a hatch directly under the fore hatch.

Steerage: Opening from the after end of the berth deck is the steerage, containing four double-berth state-rooms, 6 feet 6 inches in length, two on each side, and a mess-room 13 feet in length between. It is lighted and ventilated by an 8-inch air-port in each room, a 12-inch ventilator cut through the deck just abaft the foremast, and the door opening from the berth deck. Each room has an upper and lower berth 30 inches wide, a bureau, washstand, toilet racks, drawers, shelves, etc. On the forward bulk-head of the mess-room is an open pantry.

Lower or main laboratory (plates VI and VII): Abaft the steerage, but separated from it by a water-tight iron bulkhead, is the lower laboratory immediately below the upper laboratory, through which only can it be entered. This room extends quite across the ship, is 20 feet fore and aft, 7 feet 10 inches between decks, and is furnished with light and air by six 8-inch air-ports, two 12-inch deck-lights, and the hatch leading above.

Ample and convenient storage cases and lockers are provided for alcohol tanks, jars, and specimens in bottles of all sizes; work tables are fitted along each side; in the port after-corner is a photographic dark-room with a lead-lined sink and running water; on the opposite side is a medical dispensary, and along the bulkhead between the two is the chemical laboratory. Between the beams overhead are slings and hooks for stowing dip nets, scoop nets, harpoons, spears, lances, and other fishing appliances.

Laboratory store-room: A hatch and stairs lead to the store-room below, a closed iron box, 20 feet in length and the whole width of the vessel, capable of being isolated from the rest of the ship and filled with steam at short notice in case of fire. Here are stowed alcohol in tanks, nets, sieves, etc., for which suitable lockers have been provided. Below this store-room is a small space next the skin of the ship where the sinkers used in sounding are stored.

Engine-room, fire-room, and bunker space: The engineer's department is abaft the laboratories, and occupies 57 feet 8 inches in the hold, 47 feet 8 inches on the berth deck, and 20 feet in the deck-house.

Ward-room (plate VIII): The whole space from the laboratories aft to the ward-room is occupied by the engines, boilers, bunkers, etc. The ward-room is 38 feet in length, the full width of the ship, and 7 feet 10 inches in height from deck to deck. It is lighted and ventilated by seven 8-inch air-ports on each side, a skylight 6 by 5 feet overhead, and the stairway leading to the deck above.

The space on either side of the stairway is occupied by the pantry on one side, and the chief engineer's room on the other; the latter communicating by a door with the engine-room immediately forward. Abaft these rooms a space 13 feet in length and the whole width of the ship is reserved for an athwartship extension table, seating, at most, twelve persons. Along the sides of this space are fitted cushioned sofa transoms.

There are four rooms on each side, the starboard after one being furnished as a bath-room, the others containing a berth, bureau, washstand, drawers, lockers, etc.

Two iron doors, with water-tight joints, in the ward-room floor, give access to the paymaster's, navigator's, and equipment storerooms below, which are in a water-tight compartment. A scuttle in the pantry floor leads to the ward-room store-room, also a water-tight compartment. A door opens into a locker under the stairs.

The vessel is lighted throughout by electricity; and artificial ventilation is produced by means of exhaust fans and conduit pipes to every compartment below the main deck.

The rudder and steering gear: The *Albatross* was designed to perform much of her work stern to wind and sea, making it necessary to give unusual attention to the rudder and its appointments. The several parts are much heavier and stronger than usual in vessels of her size, and the appliances for controlling its movements are more powerful than will be found in steamers of twice her tonnage.

Rudder attachments: There is a yoke, or quadrant, on the rudderstock a little below the main-deck beams, carrying the chains to which the steel-wire tiller ropes are connected; an iron tiller on the poop deck, and a yoke for a powerful screw steering gear on the upper extremity of the stock, also on the poop deck. Projecting from the rudder a little above the water line is a short tiller, to which are attached the rudder chains ordinarily carried by steamers.

STEAM STEERING GEAR.

The steam steering gear, known as Higginson & Co.'s "steam quartermaster," was built by the Pusey & Jones Company according to the patents and design of Mr. Andrew Higginson, of Liverpool, England. The machine may be shifted from steam to hand power by the motion of a clutch, and the same wheel is used for steering by steam as by hand. Like other improved steam steerers, the valve is arranged to reverse the engine by changing the ports, and an automatic arrangement is provided to bring the valve to its middle position (and stop the engine) by gearing from the engine itself.

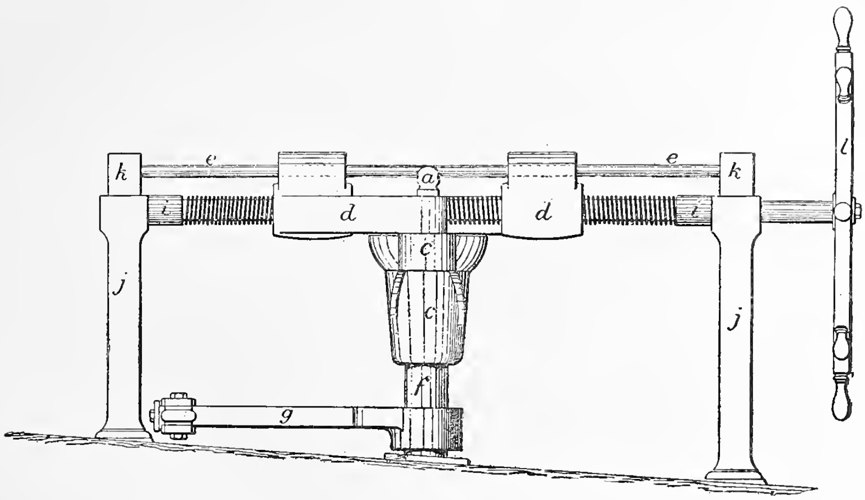
There are three half-trunk, oscillating, single-acting steam cylinders arranged at angles of 120 degrees from each other, all acting on the same crank pin, after the "brotherhood" system. The cylinders are $4\frac{1}{4}$ inches diameter and 5 inches stroke of piston. On the crank shaft is a toothed pinion which gears into a spur-wheel; on the shaft of the spur-wheel is keyed a second pinion-wheel which gears into a second spur-wheel, making the ratio of gearing nearly 36. The second pinion and the second spur-wheel are keyed to hollow cast-iron shafts, through which the other two shafts, respectively, work.

Motion is communicated to the tiller chains by a chain holder (or "wild-cat") similar to those used on patent windlasses. On the extended portion of the upper shaft there is a screw thread on which a large nut works; this nut is clutched to one of the pinions; on the forward end of the same shaft is placed the steering wheel, 5 feet 4 inches in diameter. The motion of the steering wheel communicates like motion to the clutch-nut, which, in turn, imparts motion to the slide-valve of the engines; and the motion of the engines, transmitted through the gearing described, revolves the clutch-nut upon its thread in the opposite direction, and brings the valve back to its central position. By this contrivance the engine ceases its motion directly the helmsman brings his wheel to rest. The slide-valve is common to the three cylinders; it is circular in form, and revolves upon its center by gearing from the

WARD ROOM.

steering wheel; its partitions or ribs divide it into three valves (one for each cylinder), though it is one casting. The exhaust is delivered into the steam-tight box which incloses the engine, and all the oil which the crank-pin and crank-shaft journals ever receive must come with the steam worked through the cylinders. The mechanical performance of the machine is all that can be desired. The engine starts the moment the wheel is moved and stops with equal promptness; the power of the machine is ample and it is comparatively light and compact.

Auxiliary steering-gear: This powerful screw gear is used when it is thought necessary to put the vessel stern to a heavy sea, as in sounding, and is designed to hold the rudder rigidly, thus relieving the ordinary steering-gear from unusual strains. It locks the rudder securely, and is also an efficient steering-gear which can be connected in a moment, and as quickly disconnected. A compass is conveniently placed in the cabin skylight to steer by when the after-wheel is used. Cut 3 is a longitudinal elevation, and cut 4 a plan view of the apparatus. The yoke *c* is keyed



Cut 3.—Longitudinal elevation of auxiliary steering gear.

to the upper end of the rudder-stock *f*, and the arms *d*, which have a screw-thread at one extremity working on the right and left hand screw-shaft *i*, and a hole in the opposite extremity for the reception of the pins *a*, are the means of connection between the yoke *c*, the screw-shaft *i*, and the steering-wheel *l*.

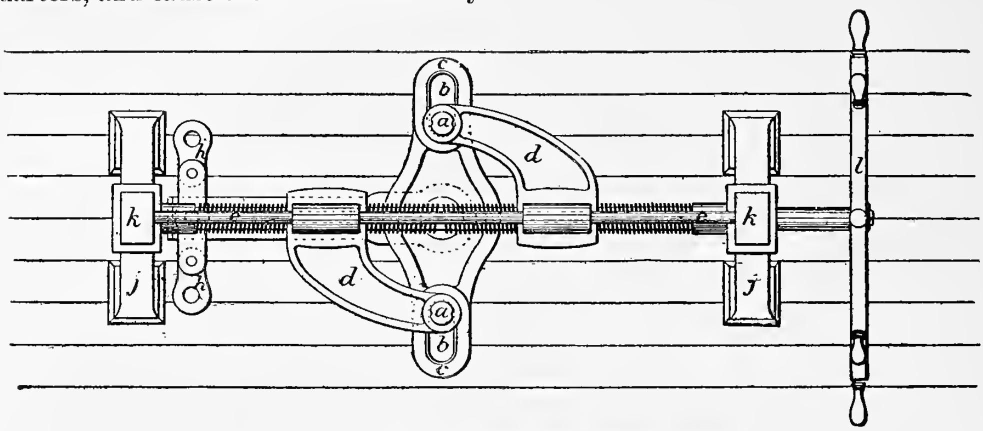
The arms *d* are held in a horizontal position by the guide-rod *e*, which is supported by the adjustable bearings *k*, which also carry the screw-shaft.

To disconnect the gear, remove the pins *a* from the arms *d* and the slots *b*, when the rudder will move freely.

Spare tiller: Cut 3 shows the spare tiller *g* keyed to the rudder-stock *f*. The eyebolts *h* for the relieving tackles slide along the whole length of the tiller, and are usually carried at the forward end for convenience in hooking in case of accident to the steering-gear.

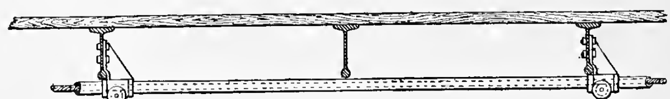
Rudder chains: The rudder chains are shackled to the short tiller projecting from the rudder, seized to an eyebolt in the stern, and carried along the quarters in the usual manner.

The tiller ropes are conducted forward through tubes and carriers, depending from the main-deck beams, which protect them from injury in the coal bunkers, do away with the annoyance and unsightly appearance of exposed tiller ropes in officers' quarters, and cause them to work silently.

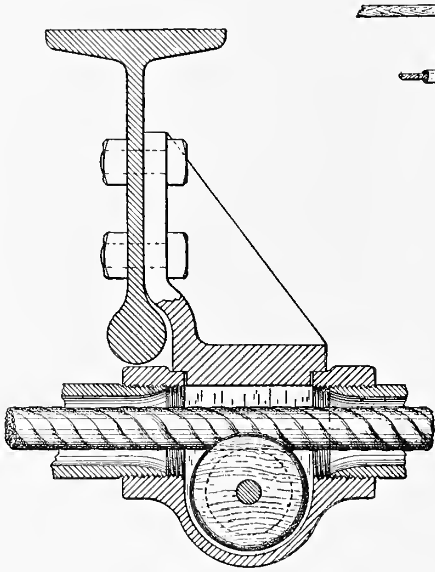


Cut 4.—Plan view of auxiliary steering gear.

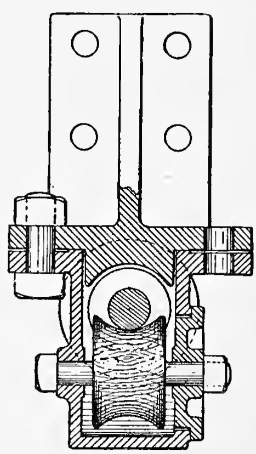
The tiller ropes are elastic steel wire, served with marline, which is thoroughly tarred. They are connected to the yoke, or quadrant, by chains spliced to the ropes and secured to the yoke by adjustable screw bolts, by means of which their tension can be regulated at will. From the yoke they are carried to the ship's side, thence



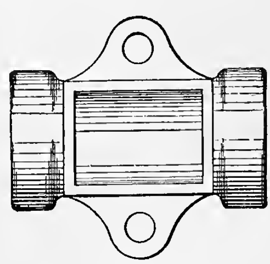
Cut 5.



Cut 6.



Cut 7.



Cut 8.

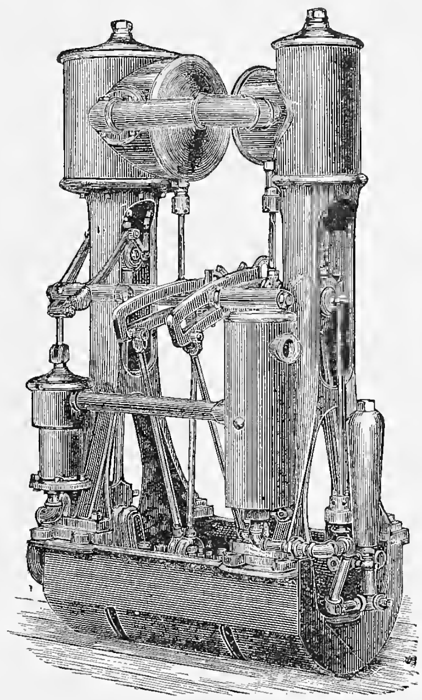
Iron tubes and carriers for the tiller ropes.

directly forward, under the main-deck beams, and spliced to the ends of a chain, which, being brought amidship through appropriate sheaves, is carried up and over the "wild-cat" of the steam steerer designed to take the links and prevent slipping.

BOATS.

The *Albatross* carries eight boats, as follows:

Herreshoff steam cutter: The Herreshoff steam cutter is 26 feet 6 inches in length, 7 feet beam, and 3 feet 10 inches in depth, with square, tubulous boiler and compound engine, cylinders 6 inches and 3½ inches in diameter and 7-inch stroke, developing 16 horsepower with 100 pounds of steam. It has a keel condenser, and carries an average of 26 inches vacuum. The bunkers hold 1,100 pounds of coal, and the fresh-water tank, which is placed directly underneath the boiler, has a capacity of 42 gallons, sufficient for three days' steaming. The hull and engine are of the best material and workmanship. Water-tight compartments at bow and stern have sufficient buoyancy to prevent sinking in case the boat is filled with water. Twelve persons can be seated comfortably in the stern sheets. In addition to steam power, the boat is provided with sliding gunter masts and sails, schooner rigged, and makes good speed under sail alone. It is cutter build, with square stern, coppered bottom, weighs 6,124 pounds, including coal and water, and has a speed of 8 knots.



CUT 9.—Engine of steam cutter.

Steam gig: Built also by the Herreshoff Manufacturing Company. Twenty-five feet in length, 5 feet 2 inches beam, 3 feet 3½ inches depth. A square, tubulous boiler, compound engine, 4¼ inches and 2½ inches diameter of cylinders, and 5-inch stroke, developing 7½ horsepower with 100 pounds of steam. It has the general form of a whaleboat, is double planked, spruce inside running diagonally, and mahogany outside running fore and aft. Both layers are bound together by brass screws at short intervals, making the structure unusually strong and light. There are water-tight compartments at bow and stern of sufficient capacity to float boat and crew in case it is filled with water. The total weight, including coal and water, is 2,907 pounds.

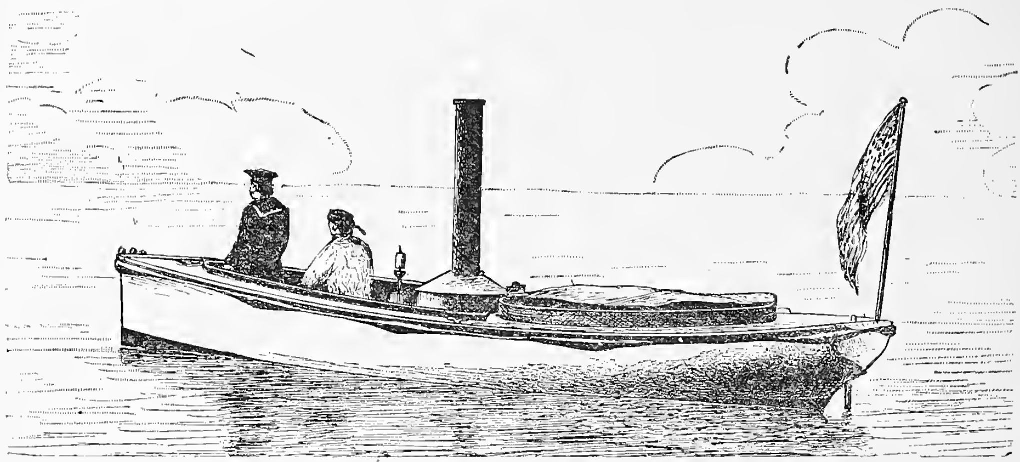
The bunkers hold 450 pounds of coal, and the fresh-water tank under the boiler carries 15 gallons, enough for two days' steaming. The ordinary speed of the boat is about 7 knots, although it can be driven to 8 for a short time. Seven persons can be seated comfortably in the stern sheets.

The location of the propeller under the bottom, about half the length from the stern, is a peculiar feature of this boat. It is so arranged that by a universal joint in the shaft the propeller can be hoisted and lowered, and when in the former position it does not project below the keel. When in use it is lowered, and no matter how heavy the sea it is always submerged; thus racing is entirely avoided. The advantages of this system are not particularly apparent in smooth water, but her performance in a sea way is remarkable. The gig is provided with a sliding gunter mast and sail, and makes good time under sail alone.

Steam can be raised in both cutter and gig in from 3 to 5 minutes.

Cutter: This boat is 26 feet in length, navy pattern, pulls 10 oars, is schooner-rigged with sliding gunter masts; she pulls and sails well, and is a good carrier.

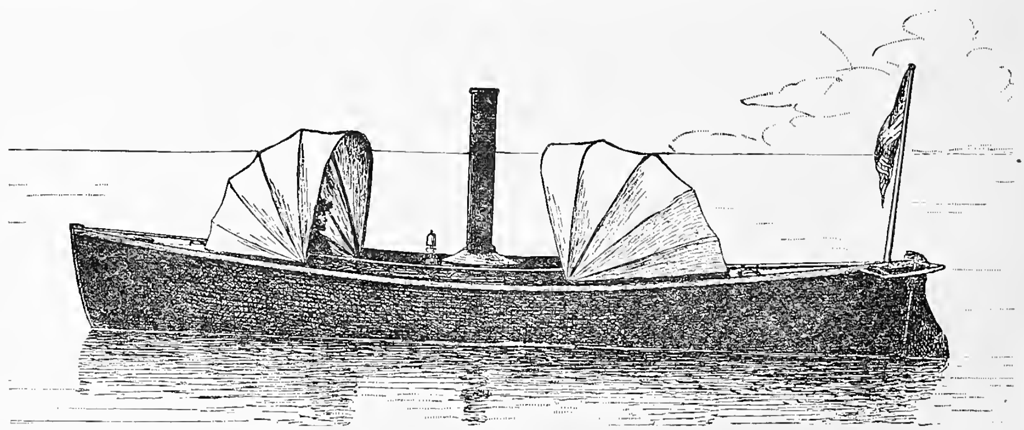
Whale-boat: A navy-built boat, 26 feet in length, pulls 6 oars, and, like the cutter, is schooner-rigged with sliding gunter masts.



Cut 10.—Herreshoff steam cutter.

Dingey: An 18-foot navy-built boat, pulls three pairs of sculls, has one mast and split lug sail.

Naturalist's boat: A small whitehall, clinker-built, centerboard boat for special use of the naturalists. It has two pairs of sculls and one mast with spritsail.



Cut 11.—Herreshoff steam gig.

Dory: A Gloucester dory, such as New England fishing vessels use in the cod and halibut fisheries. It is intended for the special use of the fishery expert.

Spawn-boat: So called from its adoption by the Fish Commission as a spawn-takers' boat. It is about 17 feet in length, has a flat bottom, deepest in midships, rising about 6 inches at either end, a sharp bow, square raking stern, flaring sides, and small sheer. It pulls three pairs of sculls, tows well from a steam launch, can be carried by two men, and is specially useful in seining and general shore collecting.

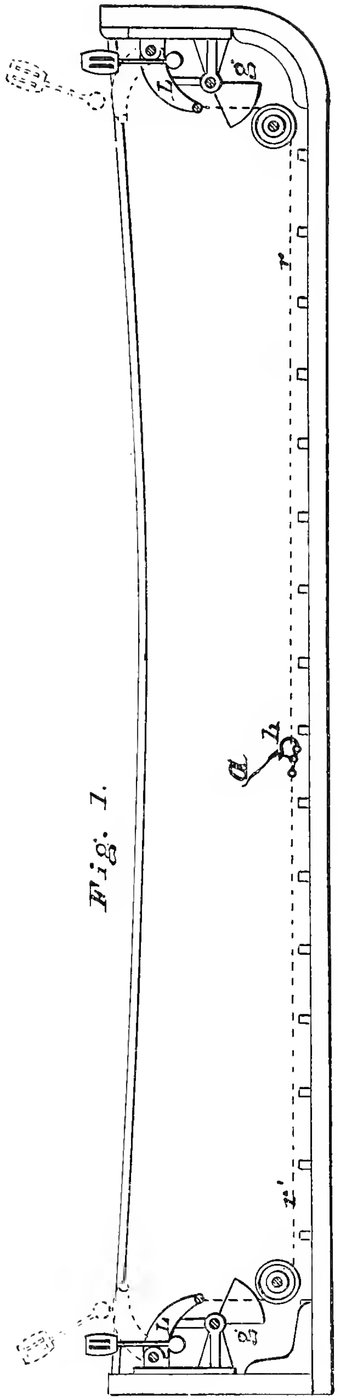


Fig. 1.

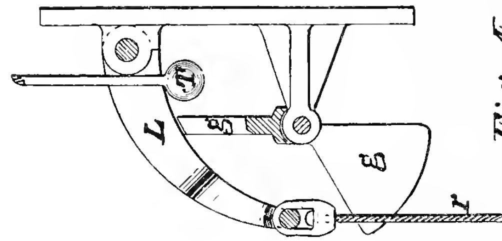


Fig. 4.

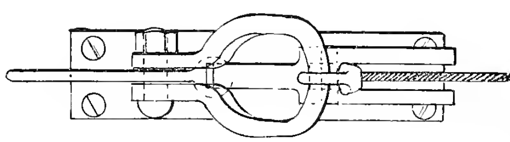


Fig. 3

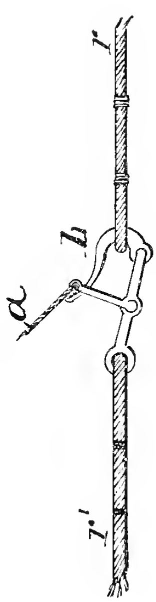


Fig. 2

LIEUT. W. M. WOOD'S BOAT-DETACHING APPARATUS.

Principal dimensions of the boats and machinery.

	Cutter.	Gig.
Length from forward edge of stem to after edge of stern ... feet	26.500	25.083
Length at the load water-line ... do	24.500	24.583
Greatest beam ... do	6.750	5
Beam at the load water-line ... do	6.400	4.833
Depth from top edge of gunwale to lower edge of rabbet of keel:		
Forward ... do	4.333	3.500
Amidships ... do	3.417	2.667
Aft ... do	3.677	3.667
Draft of water, exclusive of keel:		
Forward ... do	1.667	1.417
Amidships ... do	1.625	1.417
Aft ... do	1.583	1.417
Depth of keel:		
Forward ... do	.25	.208
Amidships ... do	.625	.458
Aft ... do	1.000	.375
Area of greatest immersed transverse section ... square feet	7.27	6.216
Area of load water-line ... do	101.65	86.67
Aggregate area of the wetted surfaces ... do	116.25	99.76
Displacement at the load water line ... cubic feet	89.29	46.86
Weight of hull and fittings ... pounds	3,300	1,700
Weight of boiler ... do	910	470
Weight of coal and water ... do	1,394	550
Weight of engine, including screw ... do	520	182
Weight of the boat complete ... do	6,124	2,902
Number of boilers ...	1	1
Diameter of casing of boiler ... inches	35	27
Extreme height of boiler from ash-pit to base of smoke-pipe ... do	$29\frac{1}{2}$	$23\frac{1}{2}$
Diameter of furnace ... do	$30\frac{3}{4}$	$22\frac{3}{4}$
Area of grate surface ... square feet	6.7	3.4
Diameter of smoke-pipe ... inches	10	8
Height of smoke-pipe above grate bars ... feet	8.75	6.75
Diameter of separator ... inches	6	3
Height of separator ... do	31	26
Steam cylinders ... number	2	2
Diameter of high-pressure cylinder ... inches	$3\frac{1}{2}$	$2\frac{1}{2}$
Diameter of low-pressure cylinder ... do	6	$4\frac{1}{4}$
Stroke of pistons ... do	7	5
Diameter of the piston rods ... do	$\frac{5}{8}$	$\frac{7}{16}$
Diameter of the air pump (single-acting) ... do	$2\frac{1}{2}$	$2\frac{3}{4}$
Stroke of air pump ... do	$2\frac{3}{8}$	$2\frac{1}{8}$
Diameter of circulating pump-plunger ... do	$\frac{7}{16}$	$\frac{3}{8}$
Diameter of feed pump-plunger ... do	$\frac{7}{16}$	$\frac{3}{8}$
Stroke of pumps ... do	7	5
Length of condensing pipes ... feet	15	$13\frac{1}{12}$
Condensing surface ... square feet	9.83	4.95
Main journals ... number	3	3
Diameter of main journals ... inches	$1\frac{1}{2}$	$1\frac{3}{4}$ and $2\frac{1}{4}$
Length of main journals ... do	3	$2\frac{1}{8}$
Crank-pin journals ... number	2	2
Diameter of crank-pin journals:		
High-pressure ... inches	$1\frac{1}{2}$	$1\frac{1}{8}$
Low-pressure ... do	$\frac{7}{8}$	$\frac{9}{16}$
Length of crank-pin journals:		
High-pressure ... do	$1\frac{1}{2}$	1
Low-pressure ... do	$1\frac{3}{4}$	$1\frac{1}{4}$
Space occupied by the engine:		
Length fore and aft ... do	$24\frac{1}{2}$	21
Width ... do	21	18
Height ... do	44	26
Diameter of the screw propeller ... do	28	$16\frac{1}{2}$
Pitch of the screw propeller (uniform) ... do	48.72	30
Projected length of the screw on line of its axis ... do	5	3
Blades of the screw ... number	4	2
Friction of the pitch used ...	0.49	0.2
Helicoidal area of the screw blades ... square feet	3.69	$\frac{1}{2}$
Weight of the screw ... pounds	45	6

BOAT-DETACHING APPARATUS.

The whale-boat and dingey are kept hanging at the davits ready for emergencies, and are provided with a unique detaching apparatus (plate IX), the invention of Lieut. William Maxwell Wood, U. S. N.

The object of a detaching apparatus is to disengage both ends of a boat from the tackles at the same time, the operation being under the control of one man. To accomplish this Mr. Wood has provided a pair of links, L, figs. 3 and 4, which oscillate freely about a center of motion. The form of this link is such as to permit the spherical toggle T to pass between its sides: now, if the link is pulled down by the chains *rr'*, and the ends of the chains connected by the slip hook *h*, the toggle will slide up in the link and be locked in the narrow space between its sides, as shown in full lines in figs. 1, 3, and 4. If, however, the slip hook *h* is tripped by pulling the lanyard *a*, figs. 1 and 2, both chains *rr'* will be slacked, and the links L released to fly up into the positions shown by the dotted lines in fig. 1, releasing the toggles and thus detaching the boat. The locks *g* are provided as a measure of safety to prevent the toggles from slipping out of the links in case one end of the boat is hoisted faster than the other, or a fall is accidentally let go; in fact, they prevent either end from being detached until the links are released by pulling the lanyard *a*.

This simple apparatus has been in constant use, at sea and in port, under all conditions of wind and weather, and has answered its purpose admirably without a single failure or accident.

STEAM MACHINERY AND ITS ACCESSORIES.

There is a two-cylinder compound engine for each of the two propellers; the engines are independent and are provided with steam reversing gears; they are upright, but not vertical, the cylinders inclining toward each other to give more room on the working-platform. There is one condenser, common to both engines, which is mounted on a bed-plate, and which forms the framing and cross-head guides for the engines; the single bed-plate supports the pillow-blocks of both engines. The condenser is of the type known as "surface condenser," and is arranged in three nests of horizontal tubes, the water passing successively through each nest, and the steam is condensed on the outside of the tubes.

There are two plunger air-pumps, placed horizontally forward of the main engines, one plunger being worked from a concentric on the forward end of each crank-shaft. Both pumps are in one casting. The feed-pumps are worked from rods extending from the air-pump plungers.

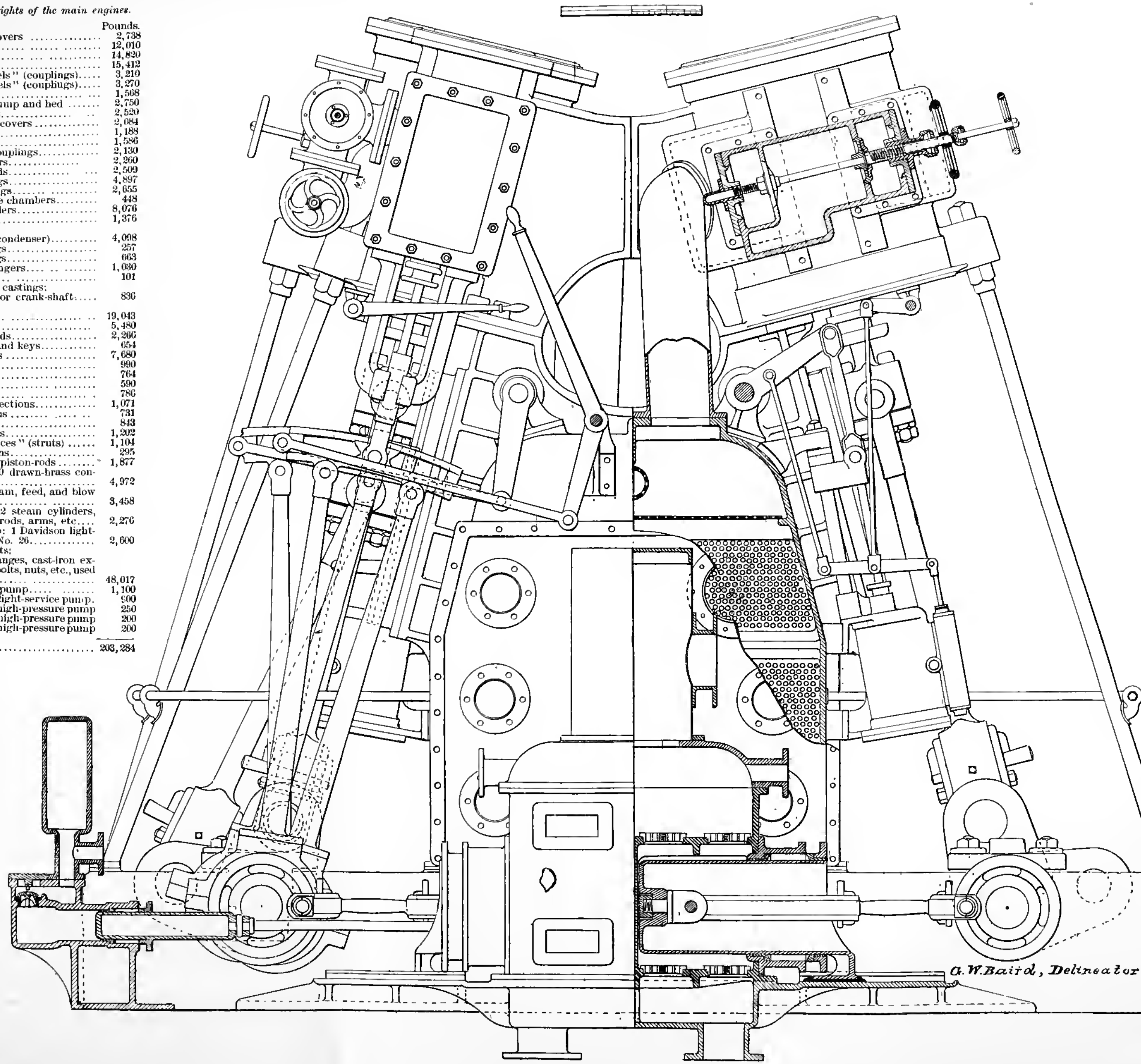
The valves of the high-pressure cylinders are locomotive slides, over which gridiron cut-off valves are placed, while the low-pressure valves are double ported and are without cut-offs. All these valves are actuated by eccentries and Stephenson links, in the usual manner.

The engines are provided with a system of valves by which they may be converted from compound to single expansion or simple engines. There are two outboard deliveries, one for the circulating water and one for the air-pump or fresh water.

The circulating pump is a Davidson light-service pump, No. 26 (cut 19).

List of the weights of the main engines.

Cast iron:	Pounds.
2 condenser covers	2,738
1 condenser	12,010
4 cylinders	14,820
1 bed-plate	15,412
2 "pinch-wheels" (couplings)	3,210
2 "crank-wheels" (couplings)	3,270
4 slide-valves	1,568
1 double air-pump and bed	2,750
4 steam-chests	2,520
4 steam-chest covers	2,084
10 eccentrics	1,188
4 pistons	1,586
4 line-shaft couplings	2,130
12 thrust-collars	2,260
4 cylinder-heads	2,509
2 stern-bearings	4,897
2 thrust-bearings	2,655
2 throttle-valve chambers	448
2 screw propellers	8,076
2 stern-pipes	1,376
Bronze castings:	
4 tube sheets (condenser)	4,098
2 stern-bushings	257
2 shaft bushings	663
2 air-pump plungers	1,030
6 link-blocks	101
Phosphor bronze castings:	
6 lower boxes for crank-shaft	836
Iron forgings:	
2 shafts	19,043
4 hangers	5,480
4 connecting-rods	2,266
4 straps, gibs, and keys	654
4 double-cranks	7,680
4 crank-pins	990
4 coupling-pins	764
6 valve-stems	590
5 links	786
Air-pump connections	1,071
Levers and arms	731
Guides	843
12 eccentric rods	1,202
4 "cylinder braces" (struts)	1,104
Link connections	295
Steel forgings: 4 piston-rods	1,877
Brass tubes: 2,400 drawn-brass condenser-tubes	4,972
Copper pipe: Steam, feed, and blow pipes	3,458
Reversing gear: 2 steam cylinders, valves, guides, rods, arms, etc	2,276
Circulating-pump: 1 Davidson light-service pump, No. 26	2,600
Additional weights:	
Floor-plates, flanges, cast-iron exhaust-pipes, bolts, nuts, etc., used in fitting up	48,017
No. 5 Davidson pump	1,100
No. 5 Davidson light-service pump	900
No. 2 Davidson high-pressure pump	250
No. 1 Davidson high-pressure pump	200
No. 1 Davidson high-pressure pump	200
Total	203,284



Principal dimensions of the engines.

Number of cylinders to each engine	2
Diameter of high-pressure cylinders ... inches	18
Diameter of high-pressure piston-rods ... do	3
Net area of high-pressure cylinders ... do	250.93
Clearance of high-pressure piston ... do	.5
Length of steam-port of high-pressure cylinder, inches	13.5
Breadth of steam-port of high-pressure cylinder, inches	1.75
Area of steam-port of high-pressure cylinder, inches	23.625
Length of exhaust-port of high-pressure cylinder, inches	13.5
Breadth of exhaust-port of high-pressure cylinder, inches	3.5
Area of exhaust-port of high pressure cylinder, inches	47.25
Number of ports in cut-off valve	3
Length of ports in cut-off valve ... inches	13.5
Breadth of ports in cut-off valve ... do	.875
Aggregate area of cut-off valve-ports ... sq. inches	35.4375
Diameter of low-pressure cylinder ... inches	34
Diameter of low-pressure piston-rod ... do	3.5
Net area of each low-pressure cylinder ... do	903.11
Stroke of all pistons ... do	30
Clearance of low-pressure pistons ... do	.5
Length of steam-ports of low-pressure cylinders, inches	20
Breadth of two steam-ports of low-pressure cylinders ... inches	3
Area of double steam-port of low-pressure cylinders ... inches	60
Ratio of volume of displacement of low-pressure piston to that of high-pressure piston, per stroke	3.599
Length of pistons, on line of axis, at circumference, inches	6
Thickness of metal in all cylinders ... inches	1
Length of packing-rings on high-pressure pistons, inches	4.5
Length of packing-rings on low-pressure pistons, inches	3.75
Diameter of each (single-acting) air-pump plunger, inches	16
Stroke of air-pump plungers ... inches	13.5
Displacement of each air-pump plunger, per stroke, cubic inches	2,814.84
Diameter of each feed-pump plunger ... inches	4.5
Stroke of each feed-pump plunger ... do	13.5
Displacement of each feed-pump plunger, per stroke cubic inches	214.7
Diameter of steam cylinder of the circulating-pump ... inches	14
Diameter of steam piston-rod of circulating-pump, inches	2
Net area of steam piston of circulating-pump, cubic inches	152.3
Diameter of water piston of circulating-pump, inches	16
Diameter of water piston-rod of circulating-pump, inches	2
Net area of water piston of circulating-pump, square inches	199.49
Stroke of pistons of circulating-pump ... inches	14
Ratio of area of steam piston to that of water piston	1:1.308
Number of brass tubes in condenser	2,394
Outside diameter of condenser tubes ... inch	.625
Exposed length of condenser tubes ... inches	66
Condensing surface of tubes ... sq. feet	2,142
Number of crank-shaft journals to each engine	3
Diameter of forward journal ... inches	7
Diameter of middle journal ... do	8.5
Diameter of after journal ... do	8.5
Length of forward journal ... do	8.5
Length of middle journal ... do	16
Length of after journal ... do	13.5

	Ft.	In.
Diameter of high-pressure crank-pins		5¾
Length of high-pressure crank-pins		7¼
Diameter of low-pressure crank-pins		7¼
Length of low-pressure crank-pins		9
Diameter of high-pressure crosshead pins		3
Length of high-pressure crosshead pins		4¼
Diameter of low-pressure crosshead pins		3¼
Length of low-pressure crosshead pins		5
Diameter of line shafts (wrought iron)		8
Length in vessel occupied by engines	9	4
Breadth in vessel occupied by engines	15	6
Height of engines above center line of shafts	12	6

COMPOUND TWIN-SCREW ENGINES

List of the weights of the main engines.

	Pounds.
Cast iron:	
2 condenser covers	2,738
1 condenser	12,010
4 cylinders	14,820
1 bed-plate	15,412
2 "pinch-wheels" (couplings)	3,210
2 "crank-wheels" (couplings)	3,270
4 slide-valves	1,568
1 double air-pump and bed	2,750
4 steam-chests	2,520
4 steam-chest covers	2,084
10 eccentrics	1,188
4 pistons	1,586
4 line-shaft couplings	2,130
12 thrust-collars	2,260
4 cylinder-heads	2,509
2 stern-bearings	4,897
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2 throttle-valve chambers	448
2 screw propellers	8,076
2 stern-pipes	1,376
Bronze castings:	
4 tube sheets (condenser)	4,098
2 stern-bushings	257
2 shaft bushings	663
2 air-pump plungers	1,030
6 link-blocks	101
Phosphor bronze castings:	
6 lower boxes for crank-shaft	836
Iron forgings:	
2 shafts	19,043
4 hangers	5,480
4 connecting-rods	2,266
4 straps, gibs, and keys	654
4 double-cranks	7,680
4 crank-pins	990
4 coupling-pins	764
6 valve-stems	590
5 links	786
Air-pump connections	1,071
Levers and arms	731
Guides	843
12 eccentric rods	1,202
4 "cylinder braces" (struts)	1,104
Link connections	295
Steel forgings: 4 piston-rods	1,877
Brass tubes: 2,400 drawn-brass condenser-tubes	4,972
Copper pipe: Steam, feed, and blow pipes	3,458
Reversing gear: 2 steam cylinders, valves, guides, rods, arms, etc	2,276
Circulating-pump: 1 Davidson light-service pump, No. 26	2,600
Additional weights:	
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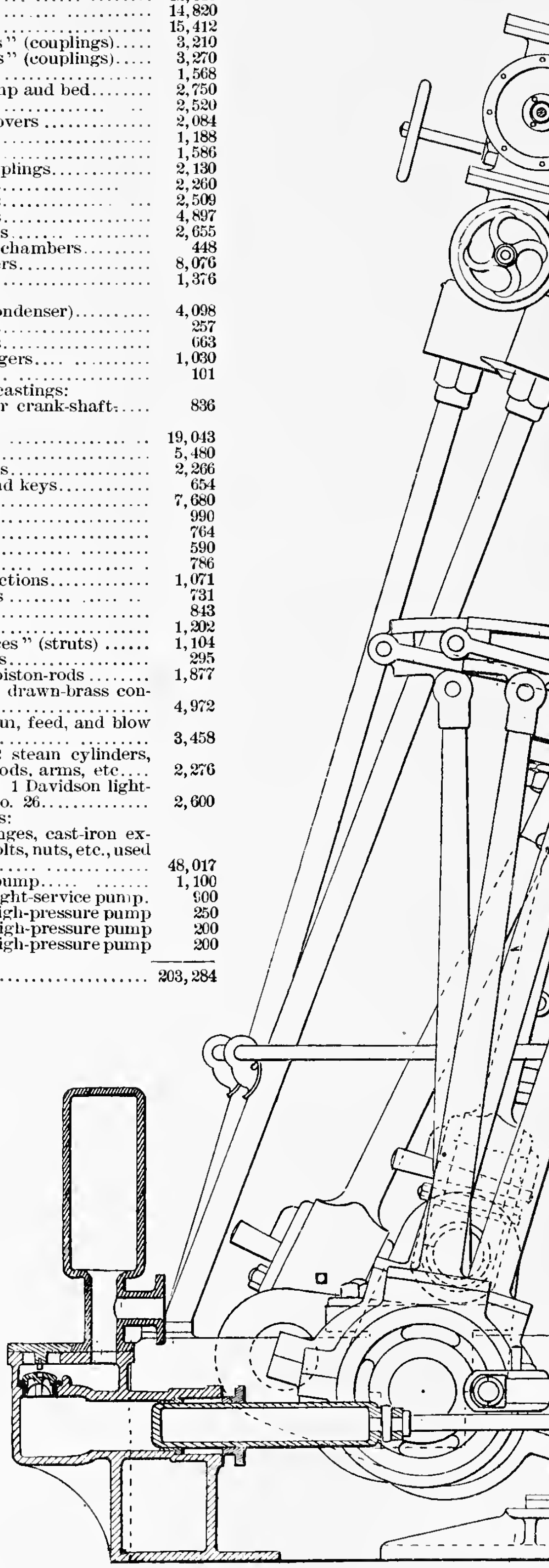
No. 1 Davidson high-pressure pump	200
No. 1 Davidson high-pressure pump	200
Total	203,284



ngines.

....	2
.inches..	18
...do....	3
...do....	250.93
...do....	.5
cylinder, ...	13.5
cylinder, ...	1.75
linder, ...	23.625
cylinder, ...	13.5
cylinder, ...	3.5
cylinder, ...	47.25
....	3
.inches..	13.5
.. do....	.875
inches..	35.4375
.inches..	34
...do....	3.5
...do....	903.11
...do....	30
. .do....	.5
ylinders, ...	20
re cylin- inches..	3
re cylin- inches..	60
-pressure r stroke.	3.599
nference, ...	6
inches..	1
pistons, ...	4.5
pistons, ...	3.75
plunger, ...	16
inches..	13.5
r stroke, ...	2,814.84
inches..	4.5
..do....	13.5
r stroke	214.7
ulating- inches..	14
g-pump, ...	2
p, cubic	152.3
g-pump, ...	16
g-pump, ...	2
g-pump, ...	199.49
inches..	14
r piston	1:1.308
....	2,394
inch..	.625
inches..	66
q. feet..	2,142
gine....	3
nches..	7
.do....	8.5
.do....	8.5
.do....	8.5
.do....	16
.do....	13.5
	Ft. In.
....	5¾
....	7½
....	7¼
... ...	9
....	3
....	4½
....	3½
....	5
......	8
....	9 4
....	15 6
....	12 6

There is a flexible coupling connecting each crank shaft to its line shaft, and the thrust bearings are on the line shafts.

The screw propellers are right and left, with four blades each.

The shaft brackets are of wrought iron; one is placed near the hub of the screw and the other halfway between this and the hull. The journals of the brackets are lined with bronze and lignum-vitæ, and the shaft in these journals is covered by a bronze jacket in the usual way.

The stern pipes are of cast iron, the after floors being bored to receive them, and the frames bent round them. The stern bearings are likewise of cast iron, with flanges fitting the hull; they are 3 feet 4 inches in length, are lined with lignum-vitæ staves, and are recessed to receive the stern pipes; the usual stuffing boxes are provided.

The sea valves are of bronze with bronze stems, seats, and glands, with cast-iron chambers, and have outside threads.

There are two escape pipes, one for each boiler, and a steam whistle forward of the smokestack. The exhaust from steam radiators and all auxiliary machinery is carried to the main condenser, the hot well, or to the atmosphere through the escape pipes, as preferred.

Engine signals are made by ordinary bell pulls on the bridge and in the pilot house, connections being made to gongs on the engine-room platform by means of wires and bell cranks.

There are three gongs, the large or main one in the center, a small one on the port side, and another of the same size, but of different tone, on the starboard side of it, all inclosed within a brass hood which is connected with a return sounding tube to the pilot house. Verbal orders are transmitted through a speaking tube having branches to the bridge, the pilot house, and sounding machine.

The following are the engine signals in regular sequence, both engines being at a stand, and to be worked together as one:

1. Jingle bell.—Cautionary. Stations for working the engines.
2. One bell, main (gong).—Ahead slow.
3. Jingle bell.—Full speed.
4. One bell, main.—Half speed.
5. One bell, main.—stop.
6. Two bells, main.—Back, ordinary full speed.
7. Jingle bell.—Back hard, open throttle.
8. One bell, main.—Stop. One bell always stops a backing engine.
9. Jingle bell, with engines at a stand.—Have finished with the engines.

The foregoing signals apply also to the starboard and port engines when they are worked independently, their respective gongs being used.

Illustrative example.—The vessel being underway and both engines at a stand, to turn sharp to starboard:

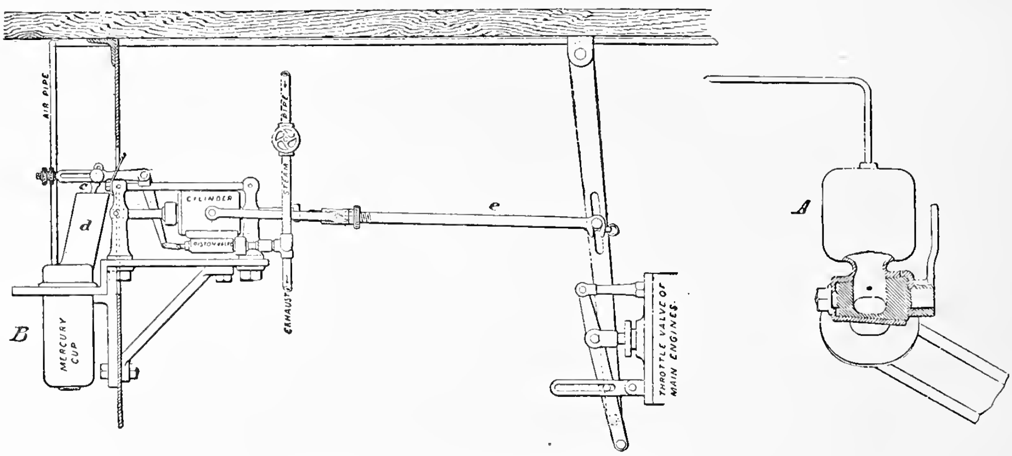
1. One bell port, two bells starboard.—Helm hard aport; engines working alike at half speed.
2. Jingle bell.—Full speed; port ahead, starboard back.
3. One bell, main.—Slow port, stop starboard.
4. One bell port.—Stop port engine.

Modifications of speed other than half or full power are effected through the speaking tube.

SVEDBERG'S MARINE GOVERNOR.

In a heavy seaway a ship, from excessive pitching, will sometimes throw the screw out of water sufficiently to relieve it of the resistance of the water; at such times the screw and engine, thus released, will spin around very rapidly, endangering the machinery. To prevent this it was formerly the custom to station a man at the throttle, who would close it when the engine began to speed up (to "race"), and open the valve when the engine slowed down. This operation was never satisfactory, and gave birth to the invention of many marine governors, the majority of which were centrifugal in principle, and consequently depended on the speeding of the engine to close the throttle, or, in other words, to slow the engine after the racing had commenced. The object of the Svedberg governor is to anticipate the racing and to close the throttle valve before it commences.

To accomplish this an air-chamber A is placed at the stern of the ship, as low down as it can be fixed; the top of this air-chamber is connected to the top of a mercury-cup by a pipe; this mercury-cup B, is made on the principle of a Wolf jar, and besides



Cut 12.—Svedberg's marine governor.

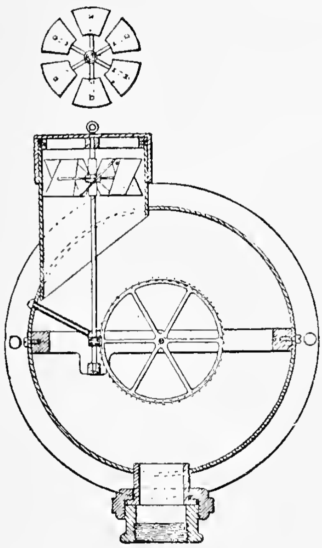
mercury it contains a wooden float on the lower end of the rod *c*, which passes through the oblique cylinder *d* to the surface of the mercury; the cylinder, though in the same casting with the mercury-cup, has its lower rim immersed in the mercury. Any elevation of the stern of the ship, or any rise or fall of the water under the stern of the ship, will increase or diminish the pressure in the air-chamber A, which pressure is promptly communicated to the mercury-cup B, and depresses or lifts the surface of the mercury in the cup; but as the lower rim of the oblique cylinder *d* is immersed in the mercury, any rise in B will depress the mercury in *d*, and will cause the float (and rod *c*) to fall or rise accordingly; and this rise or fall is directly proportional to the pressure at the stern of the ship. The pressure exerted by the float is necessarily small, while the power required to move the throttle-valve is sometimes considerable, and for this reason a steam-engine is interposed, the float moving the valve of the little engine, while the pressure of steam in the little cylinder moves the throttle. In this engine the piston and rod are fixed, while the cylinder moves upon the piston; the

valve chest and cylinder are cast in one, and the steam and exhaust pipes slide through stuffing-boxes; the cylinder is connected by the rod *e* to the throttle-valve lever.

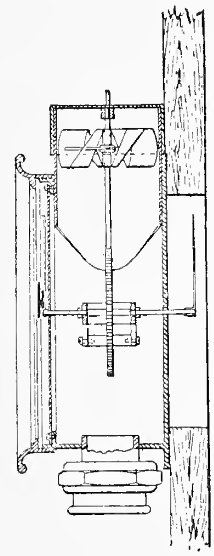
The action of the machine is as follows: The water, rolling from underneath the stern, causes a diminution of the pressure in the air-chamber, which is transferred to the mercury-cup, lifts the float and rod *c*, and, through the levers, communicates a definite amount of motion to the valve; steam is thus admitted to the cylinder and moves it to the right until its motion has equaled that of the valve, when the ports are thus automatically closed and the cylinder and throttle-valve come to rest. By changing the quantity of mercury in the cup, adjusting the length of the rods or throw of the levers, the throttle-valve can be made to come to rest at any desired position, or to work between desired limits. In practice the machine works admirably.

BAIRD'S PNEUMATIC INDICATOR.

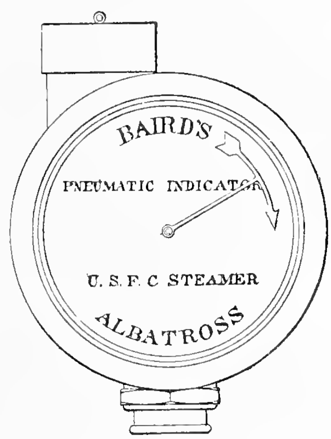
It is well known that the inertia of a steam vessel in motion is considerable, and that it requires some little time to change her direction even after the engines are reversed, and it often occurs in sounding and dredging that opposing winds and



CUT 13.



CUT 14.

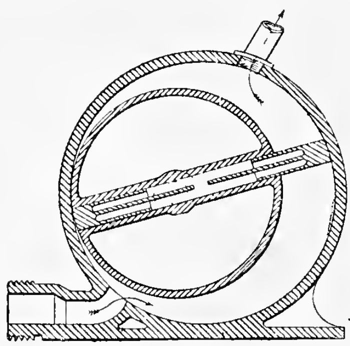


CUT 15.

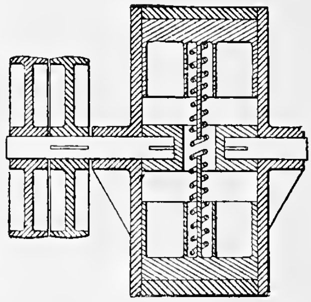
currents carry the ship from the desired position with reference to sounding wire, or dredge rope; hence it becomes imperative for the officer in charge to know promptly whether the engines are running in the right direction. The object of the indicator is to give him this information, also to show whether they are going fast or slow, or standing still.

There is an indicator for each shaft, and, having twin screws, the *Albatross* has two. Cut 13 is a sectional view of the back, cut 14 of the side, and cut 15 is a view of the face; cut 16 is a sectional view of the side, and cut 17 the end of the blower for the indicators; cut 18 is a general view of the indicator and its connections.

The indicators are of brass with steel shafts and spindles and glass faces; they are secured with their backs to the after bulkhead of the pilot-house, as seen in cut 14 with a circular hole in the wood large enough for the index arm to move in; the arrows on the faces of the indicators are visible from the deck, or bridge, those on the backs from the interior of the pilot-house.



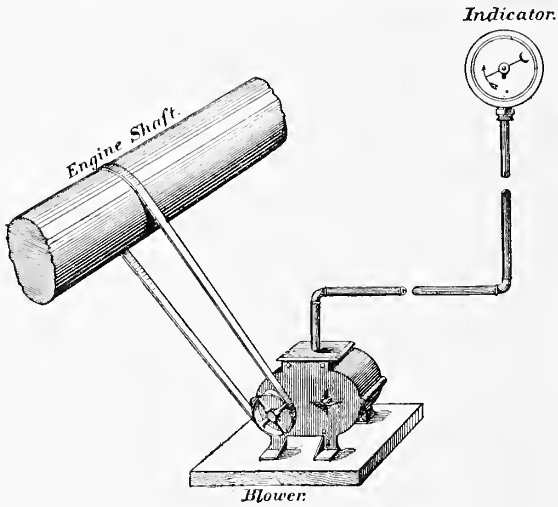
Cut 16.



Cut 17.

The index arms revolve in the direction in which their arrows point when the engines are working ahead; upon reversing them the motion of the arrows is also reversed. The index arms are mounted upon each end of a horizontal shaft carrying a toothed wheel, cut 14, which is turned by the revolution of a fan or propeller on a vertical spindle that has a worm or endless screw, the threads of which mesh with the teeth of the wheel.

The propellers are rapidly revolved by an air current when the engines move, transmitting motion through the spiral gearing to the index arms, the movement of which is moderate, but the speed is variable with the speed of the engines and incidentally affords a means of estimating by the eye their speed as well as the direction in which they are moving.



Cut 18.

The air current is derived from small rotary blowers, cuts 16 and 17, placed near the main shafts and belted to them, as shown in cut 18. When the engines are moving ahead the blowers draw the air in and force it through the pipes to the propellers in the indicator case, thence it escapes to the atmosphere.

When the engines are backing, the air is drawn in at the top of the case, reverses the propellers, and, after traversing the connecting pipes and blowers, it is exhausted into the atmosphere as before. The connecting pipes are of drawn brass of commercial pattern.

The indicators were installed early in 1886. They are simple and effective, and have greatly improved the maneuvering qualities of the vessel.

BOILERS.

There are two single-ended, horizontal return tubular boilers of the Scotch type, constructed of American charcoal flange iron and placed fore and aft on the midship line, with the fire-room athwartships between them. An annular steam drum is placed vertically over the fire-room, between the boilers, supported by wrought-iron girders which rest upon the latter, and is connected with an uptake common to both boilers.

There is a single smokestack, 10 feet of its base being formed by the steam-drum, which acts as a superheater. The grate bars are double and in two lengths.

The following are the general dimensions of the two boilers and accessories:

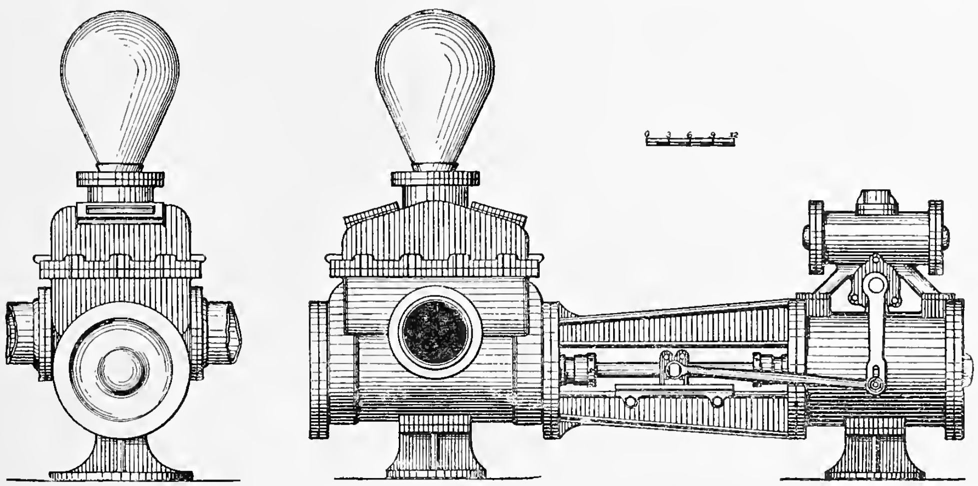
Number, 2.
Length, 10 feet 3 inches.
Diameter, 12 feet.
Number of furnaces each, 3; type, plain cylindrical, 3 sections, Adamson's rings.
Length of furnaces, 7 feet; diameter, 3 feet.
Grate surface, 21 square feet for furnace, 63 square feet for boiler; total grate surface, 126 sq. ft.
Heating surface, 1,467 square feet; total heating surface, 2,934 square feet.
Ratio of heating surface to grate surface, 23.3 to 1.
Number of tubes in each boiler, 197; material, brass; length, 7 feet 4 inches; diameter, external, 3 inches; thickness, No. 12 wire gauge.
Thickness of shell, $\frac{3}{4}$ inch; of heads, $\frac{9}{16}$ inch; of tube sheets, $\frac{3}{4}$ inch; of furnaces, $\frac{1}{2}$ inch; of connection sheets, $\frac{1}{2}$ inch.
Weight of each boiler, exclusive of grate bars, 62,333 pounds.
Weight of water in each boiler (6 inches above tubes), 31,833 pounds.
Weight of grate bars, each boiler, 4,000 pounds.
Total weight of both boilers, with water and grate bars, 196,332 pounds.

Working pressure above atmosphere, 80 pounds.
Steam drum:
  Material, American charcoal iron.
  Length, 10 feet.
  Diameter, 7 feet 4 inches.
  Diameter of flue, 4 feet 4 inches.
  Capacity, 256 cubic feet.
Smokestack:
  Total length above the grate bars, 50 feet.
  Diameter, 4 feet 4 inches.
  Weight, 3,600 pounds.
Propellers:
  Number, 2.
  Type, 4-bladed, twin-screw, right and left.
  Material, composition, 88 cu. 10 sn. 2 zn.
  Pitch: Port, 13 feet 11 inches; starboard, 14 feet $\frac{4}{10}$ inch.
  Diameter: Port, 8 feet $11\frac{3}{4}$ inches; starboard, 9 feet $\frac{1}{8}$ inch.
  Helicoidal area: Port, 30 square feet; starboard, 30 square feet.
  Weight: Port, 3,277 pounds; starboard, 3,223 pounds.

STEAM PUMPS.

The *Albatross* is provided with six Davidson steam pumps, as follows:

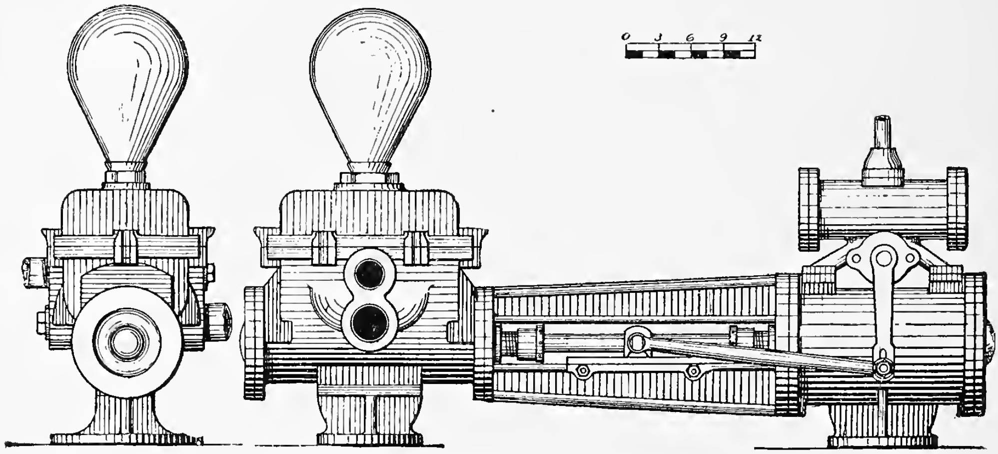
No. 1. The circulating pump is piped to take water from the sea or from the bilge, and to discharge into the condenser. Its speed may be varied from 1 to nearly 200 strokes per minute.



CUT 19.—Circulating pump.

No. 2. The boiler feed and fire pump has sea and bilge connections, and delivers to the boilers, to the hydrant pipe, engine-room, fire-room, ash-chute, and overboard at pleasure. It is designed to work under great pressure. The hydrant pipe runs fore and aft under the main-deck beams and has connections at convenient intervals on both sides of the deck-house for fire and general purposes.

No. 3. The hydrant pump is piped to take water from the sea or the bilge, and delivers to the boilers, hydrant pipe, ash chute, or overboard. It is used for the general purposes of the ship and can be worked in connection with No. 2 in case of fire or leak. The bilges are pumped through a manifold system which is common to both of these pumps.



CUT 20.—Boiler feed and fire pump.

No. 4. The auxiliary boiler feed is a vertical bulkhead pump, piped to take water from the sea, hot well, and drain tank, and delivers to boilers, ash-chute, and fire-room.

No. 5. The evaporator feed pump takes water from the sea or from the discharge pipe of the distiller and delivers it to the evaporator.

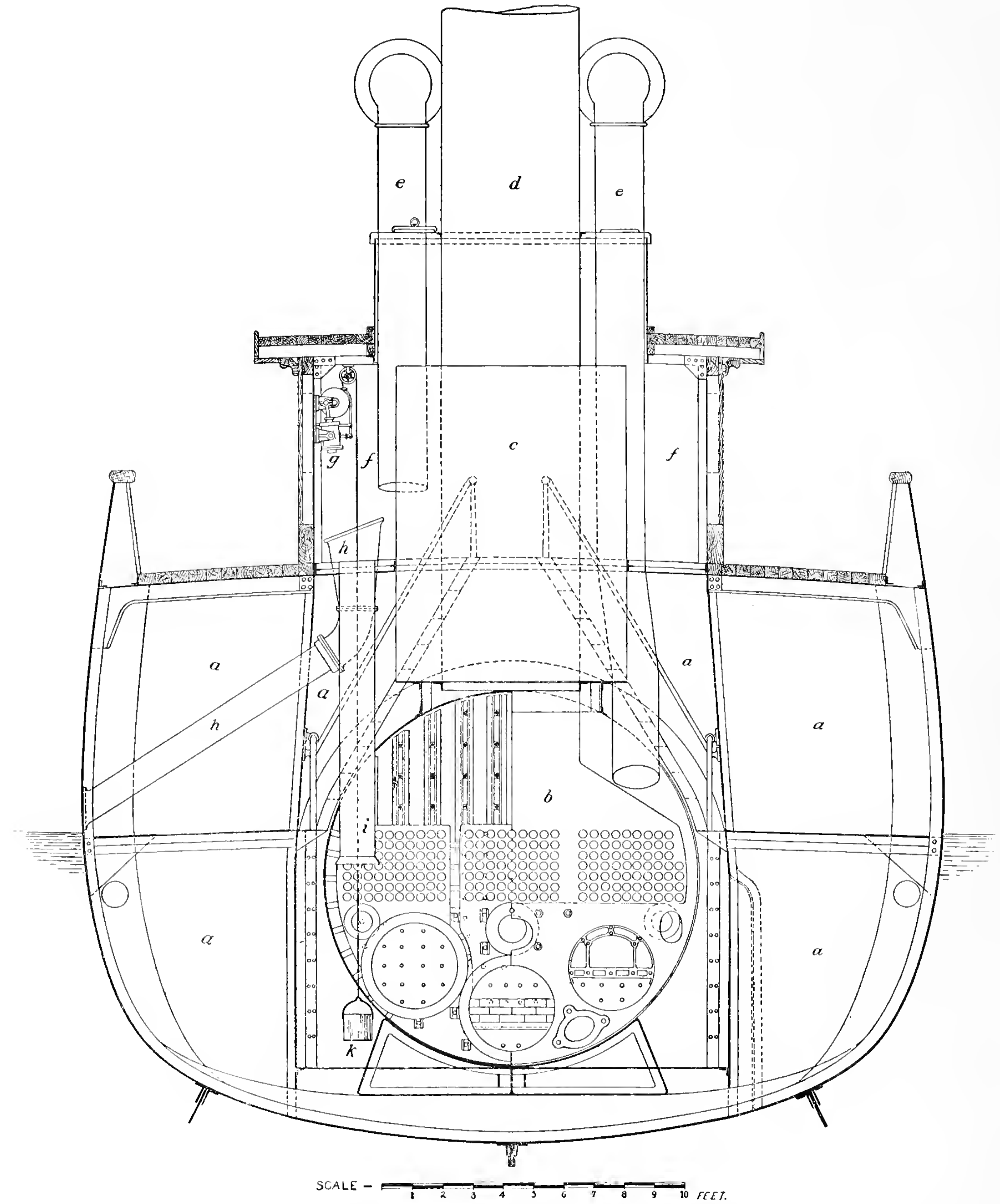
No. 6. The aquarium pump has a sea connection, and delivers water to the aquaria and bath tubs.

Table showing the size and power of steam pumps.

Ship's number.	Maker's number on size.	H. P.=high pressure. L. S.=light service.	Diam. of steam cylinder.	Diam. of water cylinder.	Inches stroke.	Gallons per stroke.	Capacity per minute at given speed, ordinary service.		Capacity per minute severe service, in case of emergency.		Weight in pounds.
							Strokes.	*Gallons.*	*Strokes.*	*Gallons.*	
1	26	L. S.....	14	16	14	12.18	86	1,047	172	2,094	2,600
2	5	H. P....	9	5¼	12	1.12	100	112	200	224	1,100
3	5	L. S.....	7	5	10	.85	120	102	240	204	900
4	2	H. P....	4½	2½	6	.13	150	19½	300	39	250
5	1	H. P....	3½	2	4	.05	150	7½	500	15	200
6	1	H. P....	3½	2	4	.05	150	7½	300	15	200

Approximate data of best four hours run (June 27, 1893).

Hours and minutes	8
Mean speed	11.52
Steam pressure	71
Receiver pressure	24
Revolutions	87.6
Vacuum	25
Throttle, holes	8
Cut-off, in decimals of stroke	.12
Temperature:	
On deck ....degrees..	50
In engine-room ....do....	106
Injection water ....do....	47
Temperature—continued.	
Discharge water ....degrees..	76
Feed water ....do....	106
Barometer	30.15
Mean draft of water ....feet..	12
Displacement in tons ....tons..	1,074
Pounds of coal consumed per hour (Nanaimo)	1,740
Square feet of grate surface in use	126
Square feet of heating surface in use	2,934
Ratio of heating surface to grate surface	23.3 to 1

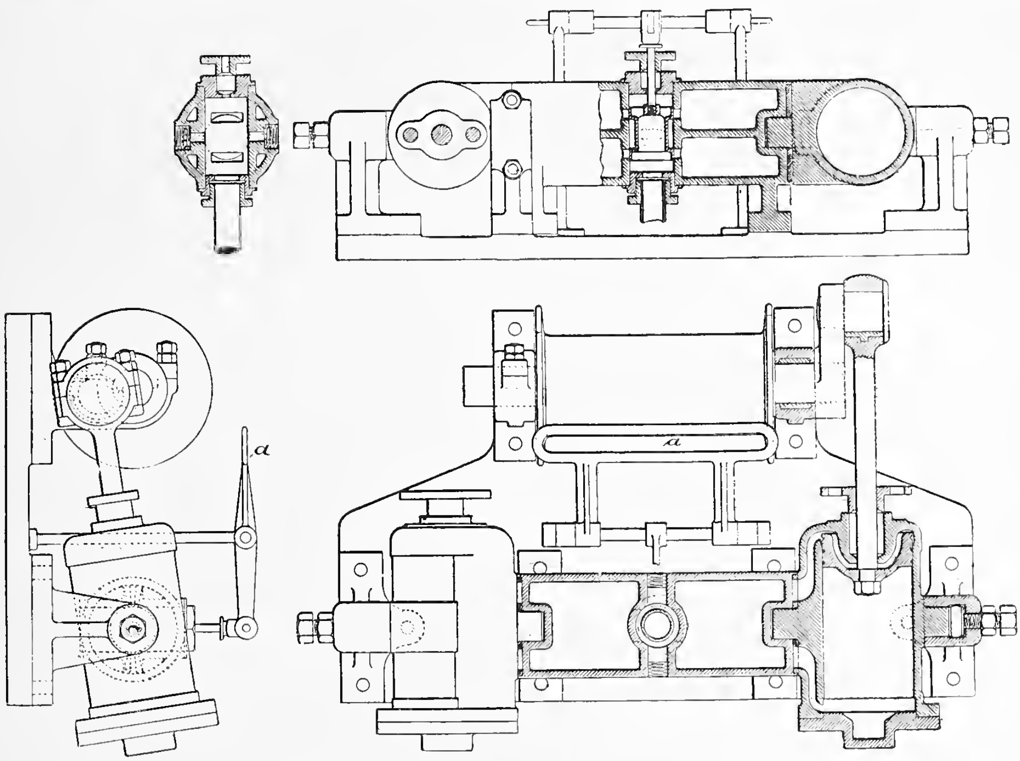


MIDSHIP SECTION OF THE ALBATROSS, SHOWING BAIRD'S ASH ELEVATOR AND CHUTE.

a. Coal bunkers.
b. Forward boiler, sectional view.
c. Steam drum.
d. Smoke stack.
e. Forward ventilators.
f. Drum room.
g. Baird's ash-hoisting engine.
h. Ash chute and hopper.
i. Vertical tube for ash bucket.
k. Ash bucket.

BAIRD'S ASH ELEVATOR AND CHUTE.

A midship section of the vessel is shown through line of fire-room, and Baird's ash-hoisting apparatus, including hoisting engine and chute, is seen on the port, or left side. The object of this machinery is to hoist the ashes and dump them overboard with the least manual labor and to avoid carrying them across the deck. The vertical chute through the ship's bottom has been tried and abandoned, as the ashes soon scoured through the bottom plates of the ship, in the wake of the chute. The steam ejectors, tried in the Navy were abandoned for the reason that the ashes, blown at such a high velocity, very quickly scoured through a 2-inch-thick cast-iron pipe; Chief Engineer George W. Baird, U. S. N., designed the diagonal tube *h* (a 10-inch wrought-



CUT 21.—Baird's ash-hoisting engine.

iron boiler flue), surmounted by a hopper, and the engine *g* referred to. A stream of water ($1\frac{1}{4}$ inches in diameter) is projected into the hopper while ashes are being dumped, and the velocity of the descending cinders, though not great, is sufficient to project them quite clear of the ship's side. The hopper and elbow are of cast iron.

Cut 21 shows several views and sections of the hoisting engine.

The principle of the engine is very old, it belonging to that class which is reversed by "changing the ports," i. e., by having an arrangement by which the steam and exhaust ports are changed, the one for the other. For simplicity and fewness of parts the crank shaft and hoisting drum are one and the same piece of cast iron; the cylinders are oscillating, their ports being on trunnions, the motion of the cylinders opening and closing the ports; the steam chest between the two cylinders is common to both,

and has at its center a piston valve; steam enters through the end of the piston valve, and by moving this valve the steam goes to one side of the chest only; by moving the valve in the opposite direction the steam would go to the other side of the valve chest, which latter is divided, by a longitudinal diaphragm, into two compartments; the exhaust is through one side of the piston valve. By this arrangement it will be seen that when this piston valve is in its middle position no steam can pass into or out of the engine, which, of course, stops it; it is also manifest that a movement of the valve in one direction will cause the engine to run in one direction, and the opposite motion of the valve will reverse the engine. The piston valve is moved by a lever which has a long slot in it (*a*, cut 21) through which the hoisting rope passes; on the rope there are two stops (knots), so situated that one will press and move the lever when the bucket *k* is up, and the other when the bucket is down. To operate the machine two men are employed; the first one fills the bucket and the second one moves the lever, the bucket rises to its stop and is brought to rest; the second man dumps the bucket into the chute, and pulls the lever, when the bucket descends to the floor and is again automatically stopped. The machine is noiseless and rapid in its action, works with certainty, and requires but little attention.

COAL BUNKERS.

The boilers are fore and aft on the midship line, and wing bunkers extend the whole length of the boiler space, 40 feet in the hold and 32 feet above the berth deck, on both sides, from the floor to the main deck. The forward and after sections are connected by arches over the boilers. The capacity of the wing bunkers is 125 tons.

The forward bunker lies between the boiler space and laboratory store-room; it extends from floor to berth deck and across the whole beam of the vessel, with a capacity of 40 tons, a total bunker capacity of 175 tons of bituminous coal. There are 8 coaling scuttles, 4 on each side, at convenient intervals on the main deck.

An auxiliary bunker has been improvised upon several occasions from the laboratory store-room by removing from it everything except the inclosed lockers, which were protected by rough boarding, leaving stowage room for 45 tons, in bags; and a gain of 15 tons could be effected by removing the lockers. Coal carried in this space is passed through the laboratory hatch. A deck load of 25 tons may be safely carried in bags, giving a total coal capacity as follows:

Wing bunkers	tons	125
Forward bunker	do	40
Auxiliary bunker, bagged	do	45
Deck load, bagged	do	25
Total coal capacity	do	235

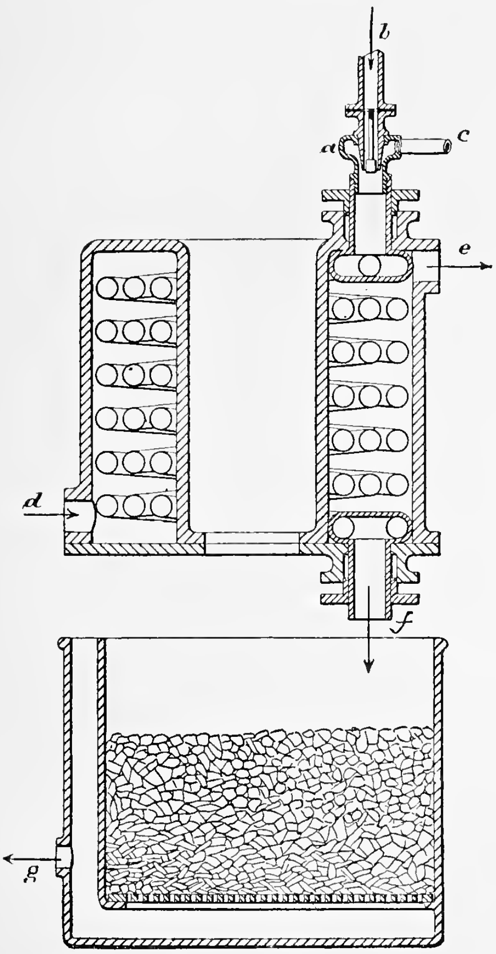
The auxiliary bunker can be utilized only by landing a portion of the scientific outfit. The steaming radius, with 235 tons of good bituminous coal, a fairly clean bottom, and good weather, is 4,500 miles at an 8-knot speed, which can be maintained on a consumption of 10 tons of coal per day.

BAIRD'S FRESH-WATER DISTILLING APPARATUS.

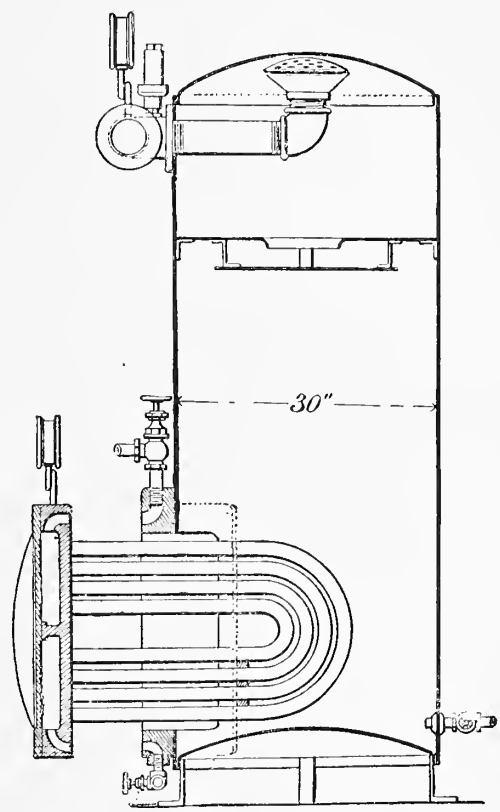
The distiller (cut 22) is patented by the inventor, Chief Engineer George W. Baird, U. S. N., and is the form generally used on board American steamships.

The object of the apparatus is to distill drinking water. There are three block-tin coils placed inside an annular cast-iron cylinder, the coils terminating in manifolds

which pass through stuffing-boxes in the heads of the cylinder. To the top of the coils is screwed an air-injector *a*, which is supplied with steam at *b* and air at *c*, the velocity of the steam inducing the air current; the steam and air thus entering, molecule to molecule, are thoroughly mixed before condensation. The current of sea-water, forced into the condenser at *d*, passing out at *e*, keeps the surfaces of the coils cool, condensing the steam within. The fresh water and air rush out of the coils at *f* and into a filter of animal charcoal, from which it is delivered to the ship's



CUT 22.—Baird's fresh-water distilling apparatus.



CUT 23.—Baird's evaporator, No. 3, Type C.

tanks through the opening *g*. The fresh water will absorb (dissolve) only a small portion of air (less than 2½ per cent of the volume under pressure of the atmosphere), but the large excess of air injected into the steam serves to oxidize organic matter which is brought over by it, and this especial filter is to remove those oxides. The object of the annular jet of steam is to bring a larger surface of steam-jet in contact with the air, and the object of the annular condenser is to compel the circulating water to flow over the condensing surface. The filtering material requires to be renewed about once in two years. The commercial size of the machine is No. 4, and

its capacity is 2,000 gallons per day; the daily consumption of water on board is about 250 gallons. A ton of coal will distill about six tons of water, so there is a saving of weight and space by employing the distiller on board ship. The quality of the distilled water is always the same, and I quote the words of an eminent medical director of the Navy in saying that "diarrhea has diminished 50 per cent on board our ships since the introduction of distilled water." The water is clear and, being well aerated, tastes quite as good as hydrant water; in fact it is difficult to detect it as the product of distillation, particularly since the evaporator came into use in connection with this apparatus.

BAIRD'S EVAPORATOR.

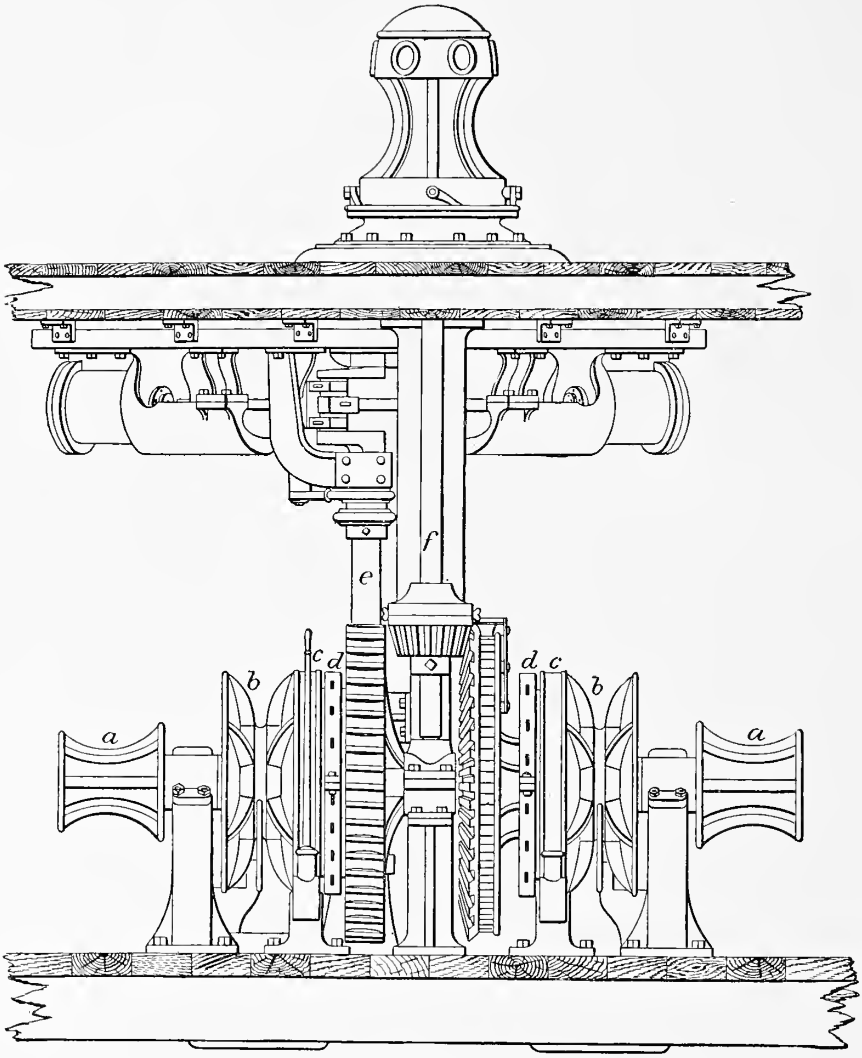
This valuable adjunct to the condensing apparatus has greatly improved the quality of the drinking water, besides providing fresh feed for the boilers. Cut 23 shows a sectional elevation of the *Albatross's* evaporator, known as No. 3, Type C. It has a cylindrical shell of steel 2 feet 6 inches in diameter and 7 feet in height. On one side is a cast-iron door and frame, the former containing a steam chest in which the ends of the copper tubes terminate. But one joint need be broken in order to remove the tubes for cleaning. They are shown partially withdrawn.

The method of operation is as follows: Sea water is pumped into the evaporator until the tubes are covered; live steam from the boilers enters at the top of the steam chest, the lower end draining to the hot well. As steam forms from the sea water it ascends through the baffle plate to the steam pipe, and thence to the distiller, or main condenser, according as it is to be used for drinking purposes or for boiler feed. Excellent results have been obtained from its use on board the *Albatross*.

THE STEAM WINDLASS AND CAPSTAN.

This machine is commercially known as the "No. 4, Providence capstan windlass," and was built by the American Ship Windlass Company. It is situated under the forecastle on the main deck. The windlass portion consists of a horizontal wrought-iron shaft, mounted in journals on cast-iron frames, and carries two gypsy heads, *a a*, two cam-clutch wheels, *d d*, a bevel gear-wheel, and a spiral gear-wheel, which are keyed to the shaft; it also carries a pair of wildcats, *b b*, and friction-brakes, *c c*, which are not keyed to the shaft. The bevel gear communicates motion to or from the capstan, and may be uncoupled by unkeying the pinion; the spiral gear is for communicating the motion of the engine to the windlass. By revolving the cam-wheels *d d* a fraction of a revolution they are coupled to the wildcats *b b*, by which means the wildcats may be made to revolve with the shaft at pleasure, and by this means the chain may be veered to one anchor while the other is hoisted; both may be hoisted or both veered while the engine is in motion. The capstan is on the forecastle deck and is keyed to the shaft or spindle *f*. This capstan, which is revolved through the bevel gears, is used for catting and fishing the anchors, for hauling upon hawsers, hoisting boats, etc. (See plate XII.)

The engines are placed horizontally beneath the forecastle deck. They rotate in the same plane, are placed at an angle of 90°, and act upon the same crank-pin. They have locomotive slide valves actuated by "loose" eccentrics, by which means the engines are reversible. The cylinders and their respective cross-head guides are in one casting, while the outer cylinder heads only are movable. The cylinders are

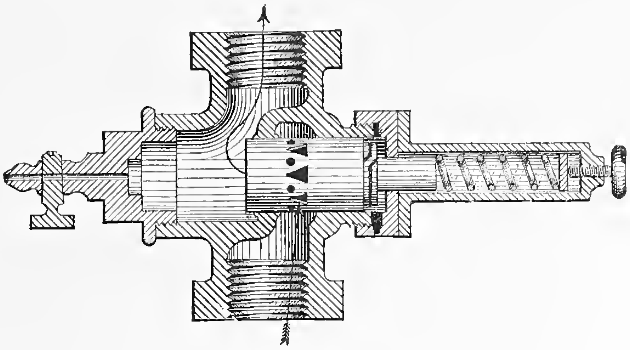


STEAM WINDLASS AND CAPSTAN.

Diameter of windlass shaft ....inches..	$3\frac{3}{4}$
Smallest diameter of gypsy heads . ...do....	$10\frac{1}{2}$
Largest (inboard) diameter of gypsy heads ...do....	15
End (outboard) diameter of gypsy heads ......do....	$13\frac{1}{4}$
Length of gypsy heads.... ....do....	$13\frac{1}{2}$
Number of whelps on wild cats	5
Size of starboard chain (diameter of iron)...inches..	$1\frac{3}{8}$
Size of port chain (diameter of iron).... .. ..do....	$1\frac{3}{16}$
Chain per revolution of starboard wild cat.fathoms..	$\frac{2}{3}$
Chain per revolution of port wildcat..........do....	$\frac{19}{17}$
Diameter of friction-brakes........ .. ....inches..	23
Width of face of friction-brakes............ ...do....	$2\frac{1}{2}$
Total length of windlass shaft ....do....	92
Number of teeth in bevel spur-wheel	49
Number of teeth in bevel pinion	12
Number of teeth in spiral gear-wheel..	52
Number of convolutions of "worm" screw thread..	4
Outer diameter of worm screw... .... inches..	8
Radial length of worm-screw threads ... .do....	$1\frac{1}{4}$
Pitch of spiral gear ....do....	$1\frac{3}{4}$
Diameter of capstan spindle . . ..do ...	$3\frac{7}{16}$
Smallest diameter over capstan whelps.. ...do....	$10\frac{3}{4}$
Projected height of capstan drum ....do....	14
Number of steam cylinders	2
Diameter of steam cylinders.. .. ....inches..	8
Stroke of pistons.................. ... .do....	8
Diameter of piston rods ....do....	$1\frac{5}{8}$
Diameter of connecting rods at neck..........do....	$1\frac{1}{2}$
Diameter of crank pin .. ..do....	$2\frac{3}{4}$
Length of crank-pin journal .. ..do....	6
Diameter of cross-head pins. ....do....	2
Length of cross-head pin journals.. ....do....	2
Ordinary speed of engine, in revolutions, per minute.	300
Rate of heaving in starboard anchor, in fathoms, per minute	4
Rate of heaving in port anchor, in fathoms, per minute	$3\frac{4}{15}$
Length of starboard chain ....fathoms..	120
Length of port chain. ....do....	120
Weight of starboard chain. .. ..pounds..	14,745
Weight of port chain............. .. ..do ...	9,283
Weight of starboard anchor and stock.........do....	2,760
Weight of port anchor and stock... ....do....	1,950
Total weight of both anchors and chains...... do...	28,737
Weight of steam capstan windlass, complete..do....	9,000

sufficiently large to hoist both anchors at ordinary depths of water, with 10 or 12 pounds of steam per square inch of piston, and for this reason a pressure-regulating valve (cut 24) is placed in the steam-pipe; by tightening or slacking the screw the steam is adjusted in the cylinders to any pressure inside the limit of the boiler pressure.

The engine takes its steam from the main boilers, and exhausts into the main condenser or into the atmosphere, as desired.



CUT 24.—Pressure-regulating valve.

The engine makes from 275 to 325 revolutions per minute; at 300 revolutions the velocity of the starboard chain would be 4 fathoms per minute and the port chain 3.4 fathoms per minute.

LIGHTING.

The *Albatross* has an electric plant for both internal and external lighting; also a complete outfit of oil lamps for burning mineral sperm. She was the first United States Government vessel to receive an electric installation for internal illumination. The original Edison electric plant furnished the vessel in 1882 consisted of a Z dynamo having a B circuit of 51 volts, driven by an Armington & Sims $8\frac{1}{2}$ by 10 inch engine, which, at 350 revolutions, drove the dynamo 1,700 turns per minute and furnished ample power and uniform speed.

There were 120 8-candle incandescent lamps in circuit, also a powerful arc lamp, which was run on the same circuit and used when a concentration of light was required at the table sieve to facilitate the work of the naturalists. The dynamo was rated at 1,200 candles by the makers, but was capable of developing much greater power. A new electric plant was installed in 1887, which represented the improvements of five years. It consists of a No. 3 dynamo, with an A circuit of 110 volts, driven by an Armington & Sims $6\frac{1}{2}$ by 8 inch engine (cut 25), which at 300 revolutions drives the dynamo 1,200 turns per minute.

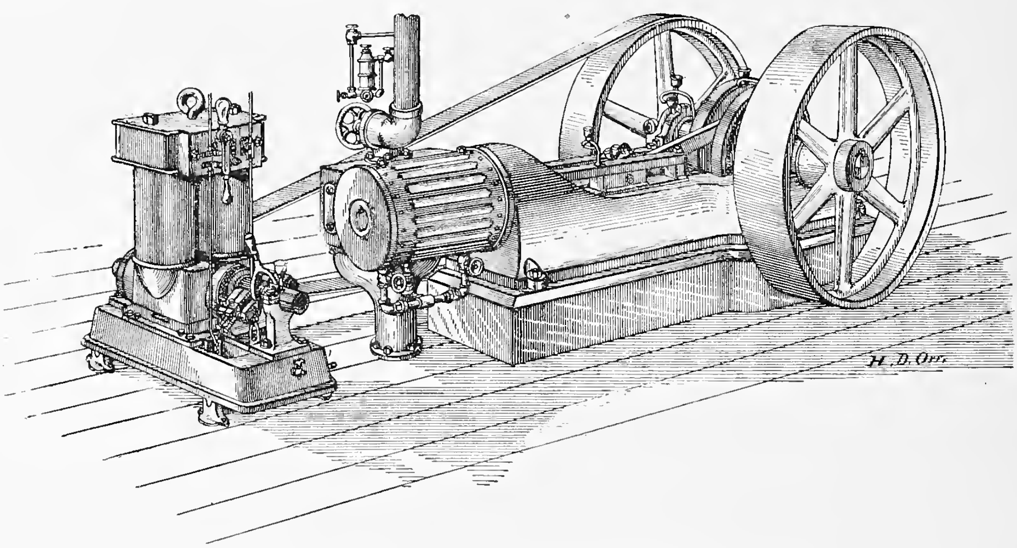
The dynamo was rated by the makers at 1,200 candles, yet it develops nearly twice that power without visible evidences of distress. There are at the present time 152 16-candle incandescent lamps in circuit, besides several portable hand lamps, which are connected as occasion requires. Of course, the lamps are never all in use at the same time, seldom more than half of them, the installation furnishing all the current needed.

The governor of this engine is fixed to the fly wheel, which is keyed to the shaft, and consists of two eccentrics, one within the other, each moving independently upon

its axis, two weights pivoted to the arms of the fly wheel with their centers of motion opposite, and two spiral springs. The weights are each connected to one of the eccentrics by an arm or rod, their centrifugal force being controlled by the spiral springs in such a manner that the motion imparted to them by the revolution of the fly wheel throws one eccentric ahead and the other back, thus diminishing their throw and effecting a shorter cut-off without changing the lead of the valve.

The governor maintains a uniform speed under all the varying conditions of service, and the uniformity of current supplied to lamps in use is preserved by an adjustable resistance box and switch placed in the field circuit.

Wiring: The original wires, all copper between Nos. 10 and 20, were insulated with woven cotton and white lead, extra covering of rubber being used where they passed through damp places; hard rubber tubes encased them where they led through bulkheads, and in hot places, such as the engine and fire rooms, they were drawn



Cut 25.—Edison No. 3 dynamo and Armington & Sims engine.

through lead pipes; the wires were covered by battens in exposed places but they were led out of sight wherever possible, a practice which was soon abandoned. There were two main circuits.

The vessel was rewired in 1893 by the Pacific Electric Storage Company, of San Francisco, Cal. The highest grade rubber-covered, moisture-proof B. & S. wire of Nos. 4, 6, 8, 10, 12, and 14 was used, all run in water-tight white-pine moldings, painted before and after the wires were run. The moldings are all in plain view and easy to get at. Extra protection is given to wires passing through bulkheads.

Circuits: There are eight circuits, as follows, all controlled by a switch board placed near the dynamo:

No. 1. Cabin and ward-room, port side.
No. 2. Cabin and ward-room, starboard side.
No. 3. Deck-house, outside.
No. 4. Drum-room, galley, deck-house rooms.
No. 5. Laboratory and chart-room, starboard side.
No. 6. Laboratory and chart-room, port side.
No. 7. Steerage, main deck, forecastle starboard side.
No. 8. Steerage, main deck, forecastle port side.

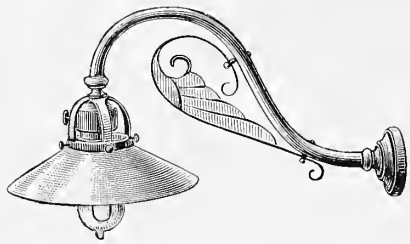


Fig. 1.

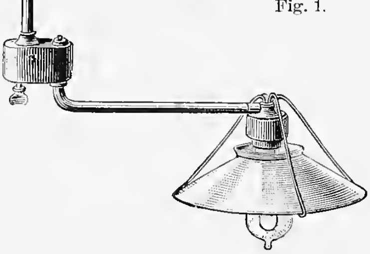


Fig. 2.

Fig. 6.

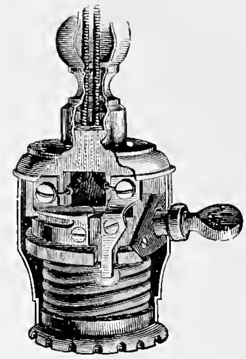


Fig. 5.

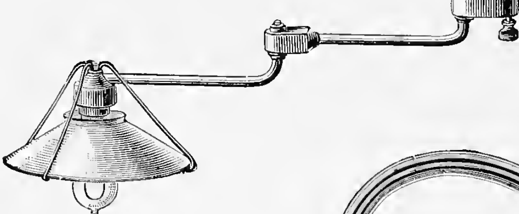
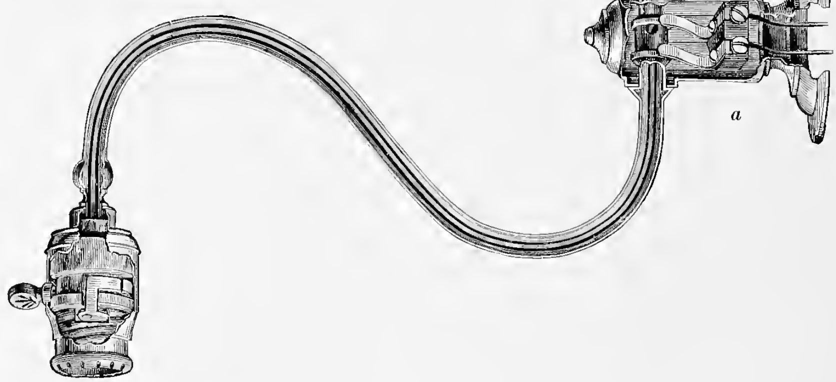


Fig. 3.



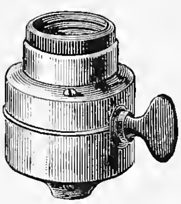
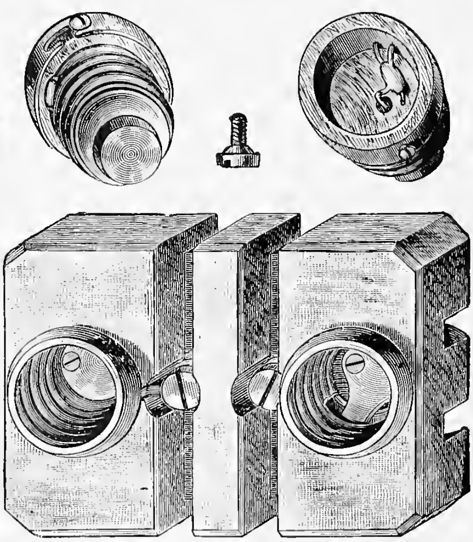


Fig. 7.

Fig. 4.



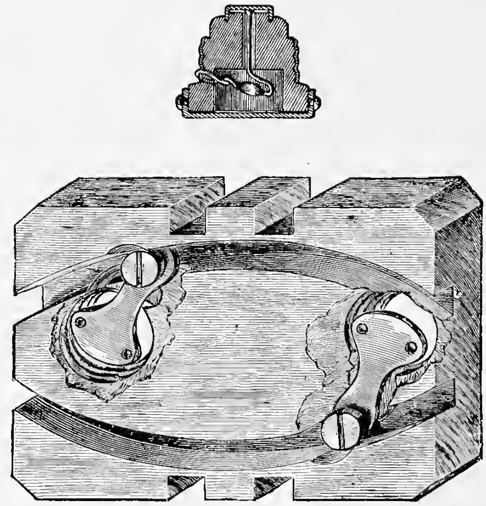


Fig. 8.

Fig. 9.

Fig. 10.

LAMP FIXTURES.

Portable electric lights: There are two small reels carrying 50 feet each of insulated flexible cable, to which 50-candle incandescent lamps are attached; one reel is in the pilot-house, the other under the forecastle, and both can be concentrated upon the table sieve, where a bright light is required for collecting and assorting specimens at night. These lamps have replaced the arc lights used for the same purpose during the first cruise of the *Albatross.* They are more easily managed and answer the purpose equally well.

Submarine electric lamps are improvised on board the *Albatross* by connecting an ordinary 16 or 50-candle lamp to one end of an insulated cable, carefully wrapping the joint to make it water-tight; a plug on the other end forms a convenient connection wherever a lamp socket is found. They are especially useful in collecting at or near the surface, lighting up the sounding machine, dredging gear, or any part of the deck remote from fixed lamps.

LAMP FIXTURES.

There are combination electroliers in the cabin and ward-room arranged to burn either mineral sperm oil or electricity or both. The bracket fixtures are designed to be suspended above and cast unobstructed rays of light downward; they are handsomely made of brass with porcelain shades, three kinds being used, called brackets, swing brackets, and double swing brackets, as shown in figs. 1, 2, and 3 (plate XIII).

The wires are run through the tubes of these brackets, but in the joints of the swinging brackets the current is transmitted through insulated hinges, to which the wires are fixed by binding screws, as shown at *a* in fig. 4, by which arrangement the wires are not twisted in swinging the bracket. The wires are brought to the binding posts in the lamp socket, fig. 5, between their binding screws and brass conductors; one of these brass conductors is soldered to the thin-spun brass socket into which the lamp is screwed, while the other is connected, through the key, to a brass disk placed centrally in the bottom of the socket, against which one pole of the lamp presses when screwed in place. The key is mounted on a screw thread of such pitch that one-fourth of a revolution will give it sufficient axial motion to open or close the circuit.

The lamps are of thin glass, pear-shaped, containing a thread of bamboo carbon about as thick as a horsehair. The small end of the lamp (fig. 6) contains glass of sufficient thickness to make a tight joint on the platinum wire conductors which carry the current to the carbon. The atmosphere is exhausted by Edison's modification of the Sprengel pump, through a tube at the lower end of the lamp, and the tube is then fused and broken off. Platinum wire is used because its index of expansion is the same as that of glass, thus preventing any breakage or leakage from the heat. The bamboo carbon and platinum wire are soldered together by electrically deposited copper. One wire, passing through the glass, is soldered to a small brass disk which is centered on the top of the lamp (fig. 6), while the other wire is soldered to the spun-brass screw thread which surrounds the cylindrical part at the top of the lamp, and when the lamp is screwed into the socket (fig. 7) the circuit is completed or broken by the switch or key already described.

When the circuit is closed the carbon thread becomes heated to incandescence—from its high resistance—and continues to glow, in vacuum, without burning, so long as the current continues to flow. Fig. 8 shows a lamp screwed into its socket.

By varying the length, and also the sectional area of the carbon thread, keeping the electro-motive force constant, Edison has varied the candlepower of his lamps.

Sixteen candlepower lamps are in general use on board the *Albatross*. The copper wires, being of high conductivity and of ample size, carry the current with but little warming, notwithstanding the white heat of the carbons in the circuit; by varying the size of the wires it will be found they follow the same law as to resistance and heating as the carbons.

Let $R =$ the resistance of a conductor; $S =$ its sectional area; $L =$ its length; $a =$ constant depending on material of which the conductor is made; then $S R = a L$, and from this simple equation the relative sizes of the wires and carbons have been determined.

The "lifetime" of these lamps is warranted to be 600 burning hours.

SAFETY CATCHES.

In event of a "short circuit" (an accidental connecting of the + and − wires) by a good conductor there would instantly be generated sufficient heat in the wires to melt them and to set fire to the adjacent woodwork, and possibly melt the armature also. To prevent this, Mr. Edison has devised his cut-out blocks and safety plugs, shown in figs. 9 and 10 (plate XIII). The wires of the circuit connect to the binding screws in the blocks, while the plugs screw into the sockets of the blocks when the circuit is completed through the plugs, after the manner of the lamps; but the wire which connects the two poles of the plug is made of a fusible alloy, which melts at about 400 degrees, and the melting of this wire breaks the circuit. When this happens all the lamps fed through that plug will go out. These safety catches are placed on the main wires near the dynamo and on every branch circuit near the point where the mains are tapped.

VENTILATING.

Natural ventilation is provided by large air-ports and skylights which, under ordinary conditions, afford sufficient circulation to insure normal hygienic conditions, but, to guard against the discomforts of closed ports and skylights in stormy weather, and to insure the safety of the laboratories where large quantities of inflammable material and volatile liquids are carried, the vessel is provided with a simple system of artificial ventilation capable of supplying over 7,000 cubic feet of air per minute.

The plant consists of a pair of Sturtevant No. 5 Monogram exhaust fans, driven by an upright engine belted to them. The conduits are of Root's spiral galvanized-iron pipe. Those leading forward are 9 inches and those leading aft 7 inches in diameter, both diminishing in size to 3 inches in diameter at the extremities of the ship. They run fore and aft on both sides just under the lodger plates of the berth deck, and branch pipes 3 inches in diameter are carried up through the deck to the apartments to be ventilated.

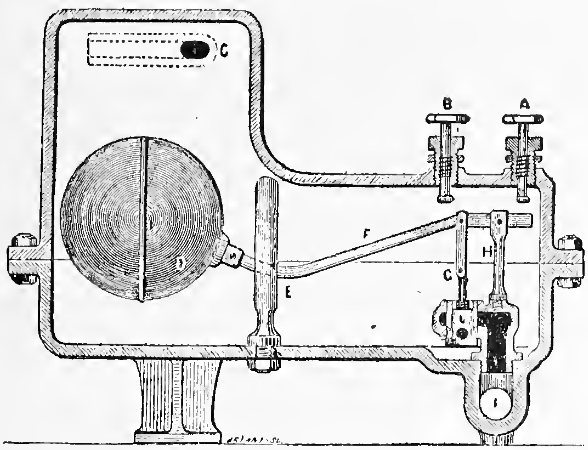
Each pipe terminates in a polished brass register, easily worked by hand, and air and water tight when closed; sliding gates in the conduits control the volume of air exhausted from different compartments and shut off communication in case of fire. The air is rapidly changed by running the fans even at a moderate speed, when there follows a notable absence of odors peculiar to ships, of stuffiness in the sleeping apartments, of headache and nausea on waking in the morning, and of dangerous accumulations of gas in the laboratories.

WARMING.

The *Albatross* is warmed by the simplest form of steam radiators, 1 square foot of radiator surface being allowed for every cubic foot of space to be heated. The discharge is trapped and the water conveyed to the hot well. Much trouble was experienced with the traps from lack of sufficient head until Chief Engineer Baird devised one (cut 26) which performed its work satisfactorily.

The wheels A and B are used only when the valve J becomes clogged or sticks.

The operation of the trap is as follows: When the steam and water enter it at C and rise to the floating points of the ball the water lifts it and opens the valve J enough to bring the port holes in it opposite the holes in the cylindrical case in which it works, and discharges the water at I into the hot well.



A. Valve wheel by which the lever F is raised, thus opening the trap by hand.
B. Valve wheel by which the lever F is lowered, closing the valve by hand.
C. Inlet to receive the discharge from the radiators.
D. Copper ball, or float, heavy, and brazed at the joints so that it can not collapse or leak.
E. Guide in which the lever works.
F. Lever operating the float and valve.
G. Connecting rod between the lever F and piston valve J.
H. Stud supporting lever F and float D.
I. Outlet or discharge.
J. Piston valve.

Cut 26.—Baird's Automatic Steam Trap.

Baird's trap has the following advantages:

1. It has a perfectly balanced valve, which operates equally well with high or low pressures.

2. The area of the openings in the valve are equal to the inlet and discharge pipes, which prevents the trap from being flooded.

3. It has a drain pipe through which all water or sediment can be blown out from the bottom, or, being left open, keeps the trap dry when the radiators are not in use.

THE DEVELOPMENT OF DEEP-SEA SOUNDING.

The ordinary lead and line sufficed for navigational and other purposes until near the middle of the present century, when the needs of deep sea investigation and submarine cable surveys called for improved methods. A device for detaching the weight was recorded in the seventeenth century, showing that attention was attracted in that direction at an early day. Among the earliest recorded soundings of considerable depth may be mentioned that of Ellis, in 1749, off the west coast of Africa, where he reached bottom in 891 fathoms.

In 1819 Sir John Ross sounded in 1,000 fathoms, bringing up a satisfactory bottom specimen in the "deep-sea clamm" designed by him the previous year, and described as follows:

> A large pair of forceps, kept apart by a bolt, and the instrument was so contrived that on the bolt striking the ground a heavy iron weight slipped down a spindle and closed the forceps, which retained within them a considerable quantity of the bottom, whether sand, mud, or small stones.

Officers of the United States Navy and Coast Survey were particularly active in their intelligent and systematic efforts to reach a reliable and accurate method of deep-sea sounding, but the results were meager so long as they retained the rope of large cross-section and nondetachable sinkers of insufficient weight.

The causes for the many failures are made sufficiently obvious by reference to Professor Trowbridge's remarks regarding the resistance of rope in sounding:

> The resistance of the line varies, first, as the square of the velocity; second, as the diameter of the line; third, as the length of the line immersed.

With the above rule in mind, and the fact that a hemp line in sea water is only one-fourth its weight in air, and that its naturally large cross-section is increased by saturation, it will be seen that even in moderate depths the continued action of resistance and the deflective force of currents may approximate to the weight of the lead, and the line, left to sink slowly by its own weight, will continue to run out indefinitely, giving no warning when bottom is reached.

The following reports of soundings made in the Atlantic Ocean and Gulf of Mexico by United States and British naval officers serve to illustrate the primitive appliances and methods of the time and accentuate the great importance of later experience and inventive genius.

Lieut. M. F. Maury, United States Navy, who was always foremost in every effort at advancement, advocated the use of a small line of great strength, made of the finest flax, and a largely increased weight of sinker. The new line weighed less than 10 pounds to the nautical mile, and was measured, waxed, and carefully wound on reels of convenient size when issued for use. Naval vessels were furnished with it about 1850, and some notable successes were achieved by its use, showing that it was a move in the right direction; yet frequent failures and discouragements were encountered.

Lieut. William Rogers Taylor, of the U. S. S. *Albany*, introduced the systematic use of the time interval, which was an important improvement and continued to be a marked feature in deep sea sounding until the successful introduction of wire, when its importance greatly diminished; indeed, it was of no service as far as the sounding

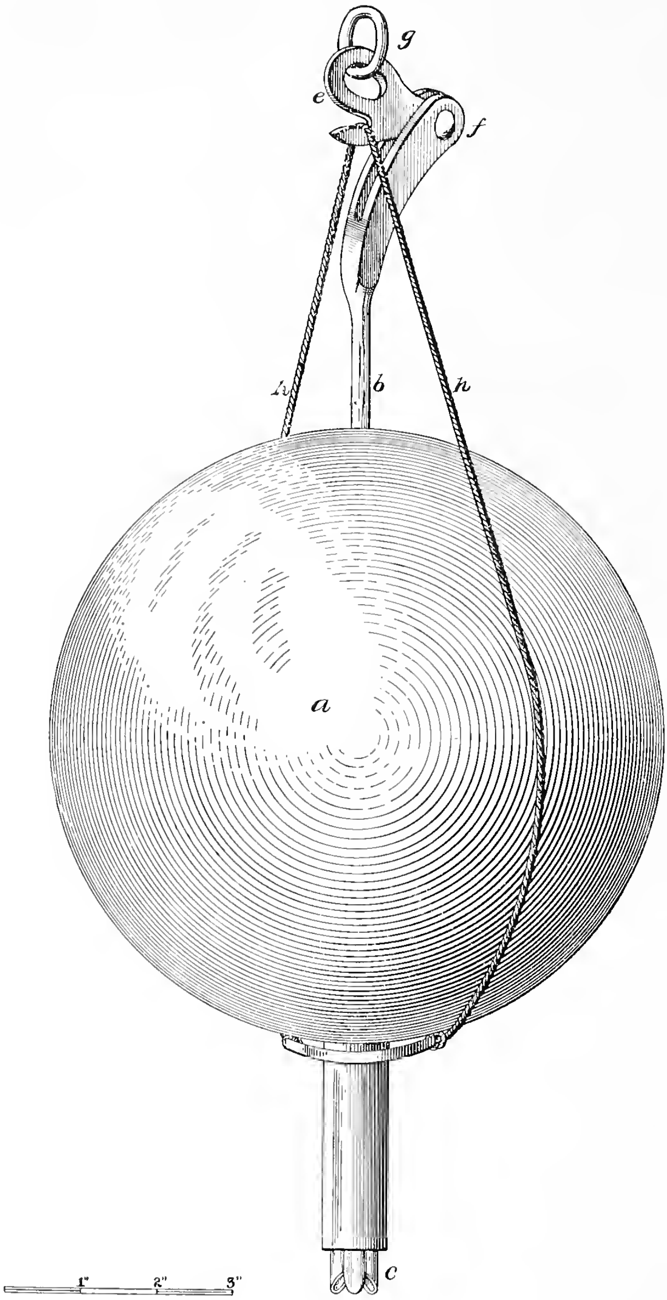


Fig. 1.

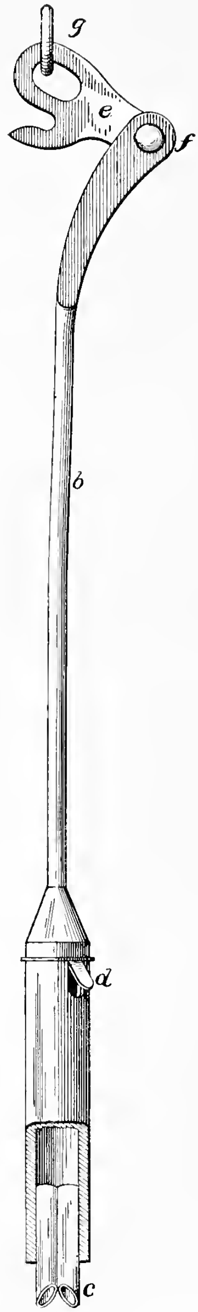


Fig. 2.

Nomenclature.

a. Sinker.
b. Soundingrod.
c. Quills.
d. Circulating valve.
e. Detacher.
f. Pin.
g. Link.
h. Slings.

THE BROOKE DEEP-SEA SOUNDING APPARATUS.

FIG. 1. Rod inserted in the sinker and the latter suspended to the detacher ready for sounding.
FIG. 2. Sectional view of the detacher in position for releasing the slings; it shows also the lower part of the specimen cup in section.

itself was concerned, but was and is still recorded to show comparative results under the varying conditions of actual practice.

The explorations of the U. S. S. *Dolphin* from 1851 to 1853, under Lieutenants Lee and Berryman, were accorded a prominent place among the notable achievements of the day. They used the apparatus just described, introducing from time to time such improvements as experience suggested, and under their hands the science of deep-sea sounding rapidly approached a practical basis. They sounded from boats, which were held in position by the use of the oars, operations being confined to smooth or moderate weather. They used waxed twine, observed time intervals, and, the sinker having reached the bottom, the sounding line was cut, no effort being made to recover the weight. Submarine telegraphy was assuming great importance in the public mind at that time, stimulating invention in everything pertaining to the development of ocean depths.

BROOKE'S DEEP-SEA SOUNDING APPARATUS.

In 1854 Passed Midshipman John M. Brooke, United States Navy, devised a simple and effective method of detaching the sinker and bringing up a specimen of bottom soil. This timely invention (plate XIV) marked the beginning of an entire revolution in the appliances and methods of deep-sea sounding and remains the acknowledged progenitor of all the various forms of sounding rods and detachers that have been introduced to the present time. It is no longer used in its original form, yet a brief description will be given to show how completely the principle of his apparatus is retained in all subsequent modifications, which are little more than successive refinements of his simple mechanism.

The sinker is a spherical shot cast with a hole through it and shallow grooves on opposite sides to guide and steady the slings. A number of goose quills are shown in the lower end of the specimen cup, held in place by their own elasticity, intended to act as collectors and foot valve. A leather circulating valve opens outward from the upper end of the cup, which allows free circulation of water through it during its descent, but closes and protects the contents while it is going up.

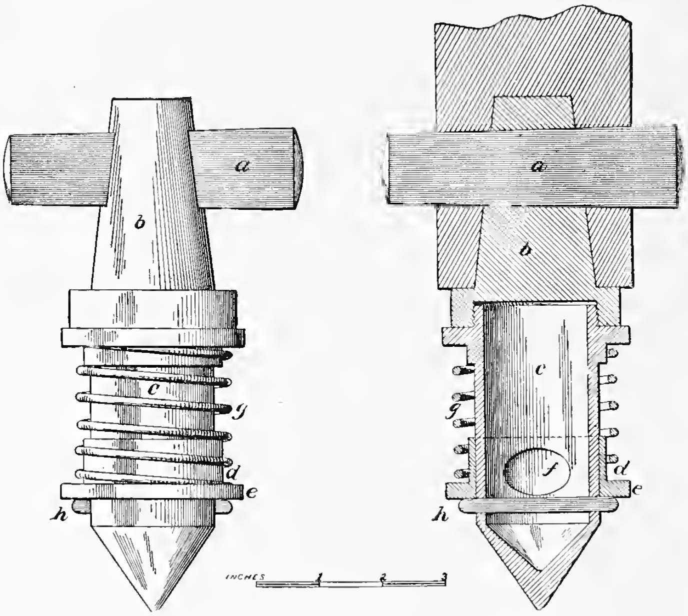
The rod and detacher are so designed that the former retains a vertical position during the descent of the sinker. When it reaches the bottom its weight is removed from the detacher and the latter falls by its own gravity, thus releasing the slings and freeing the sinker from the rod after it has performed its function of carrying the latter rapidly to its destination and pressing it into the bottom soil to secure the desired specimen.

In 1856 the U. S. S. *Arctic*, Lieutenant Berryman, made a cable survey from Newfoundland to the coast of Ireland, which may be considered the first deep-sea sounding expedition in which an approach to modern appliances and methods was successfully used. The line was of flax, 1 inch in circumference, wound on a steam reel arranged to work from the bow of the vessel. The Brooks apparatus was used with sinkers about 150 pounds in weight, and the depths were checked by a Massey self-registering sounding machine.

The results of the survey, although accurate for the time, were at first somewhat discredited from their having discarded the time interval, but in the light of modern experience it is evident that the officers of the *Arctic*, who were certainly the best judges, considered their methods and results reliable without its use. The secret of

their success is attributable to the Massey machine combined with a comparatively heavy detachable sinker, controlled in its descent by an intelligent application of the friction brake, which stopped the reel promptly when bottom was reached. The line weighed about 200 pounds to the nautical mile and would have carried a sinker of 500 pounds with safety, thus materially increasing the rapidity and accuracy of the work.

The Stellwagen and the Sands cup leads, with nondetachable weights, were among the many devices brought forward for sounding. They were both excellent for use in shallow water, or moderate depths where the lead can be recovered.



Cut 27.—Sands cup, side and sectional views.

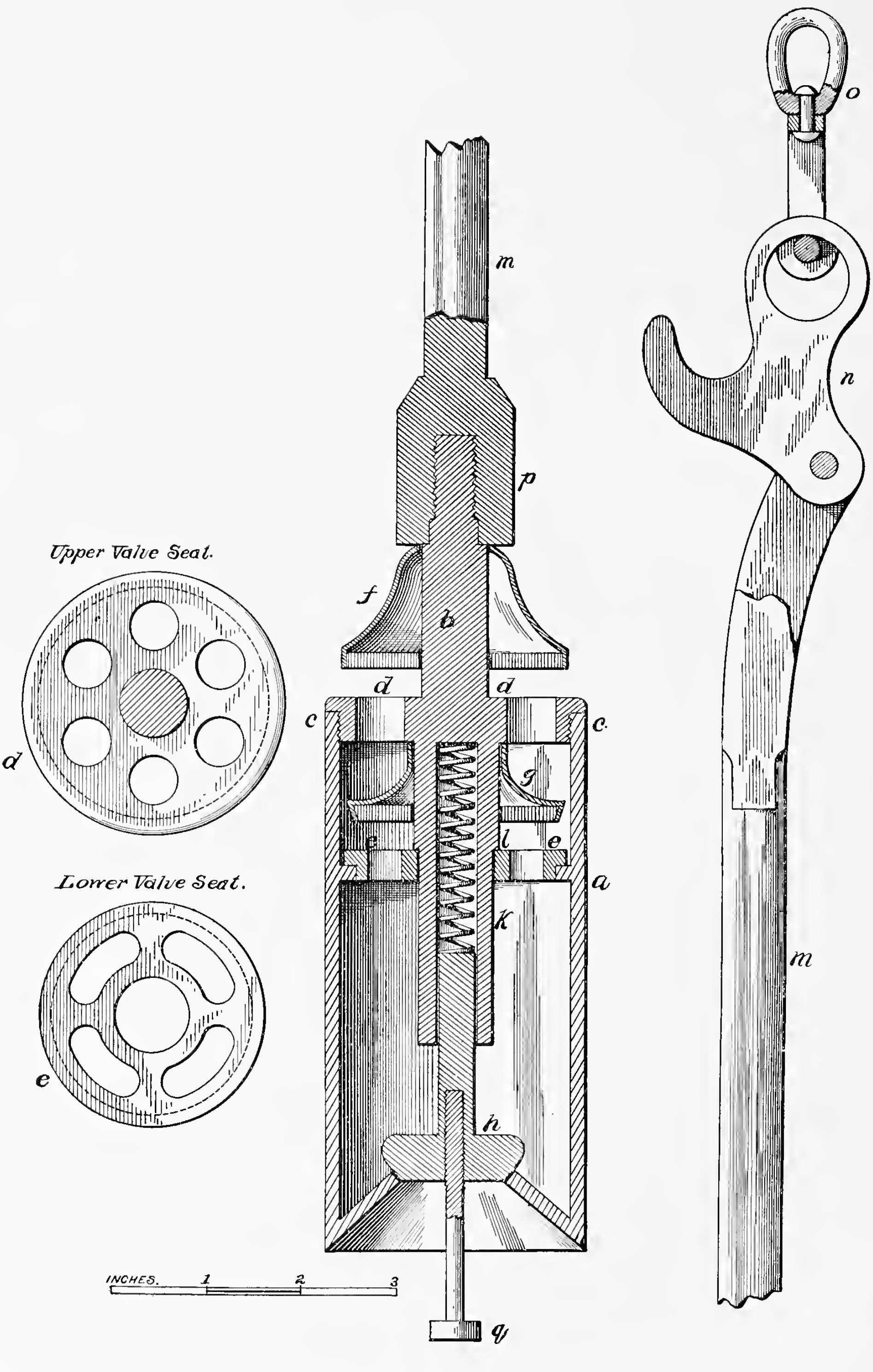
Belknap describes the Sands cup as follows:

A key, *a*, holds the tenon *b* into the bottom of the deep-sea lead, into which tenon is screwed the tube *c* (which is conical at the lower end for penetrating the bottom), over which moves a cylindrical sliding valve *d*, with flange *e*, which, resting on the bottom when the lead reaches it, is pushed up above the elliptical hole *f*, in the side of the tube for the admission of the specimen, and closed by the spiral spring *g* (when the lead is free from the bottom), which keeps it firmly down on the rest-pin *h*, preventing the washing out of the specimen in the jerking motion of hauling in the line by hand. The tube is unscrewed from the tenon, and the specimen emptied out at the upper end.

The material of the specimen cup is brass; it is easily attached to an ordinary deep-sea lead, and may be used to advantage in moderate depths. Sands subsequently added to his cup a detachable sinker composed of two hemispheres of cast iron with suitable grooves on their flat surfaces to take the rod where they were held in place by appropriate studs and springs, which also released them on contact with the bottom.

British naval officers were also active in deep-sea sounding and did much toward its advancement; the "bull dog" apparatus, a modification of Ross's "deep-sea clamm," was introduced in 1860. The forceps are retained but the weight is detachable. The Fitzgerald and Hydra, both having detachable weights, were brought out in 1868, and the latter was successfully used on the *Porcupine* during her scientific cruise, where with a line 0.8 inch in circumference, weighing 125 pounds to the nautical mile, and detachable sinker of 336 pounds, they reached bottom at a depth of 2,435 fathoms at the mean rate of 72 fathoms per minute, about seven-tenths of the best modern practice with wire.

This was evidently an exceptional sounding, made under the most favorable conditions, and can not be accepted as average work, yet it shows marked improvement, the result of increased weight of sinker.

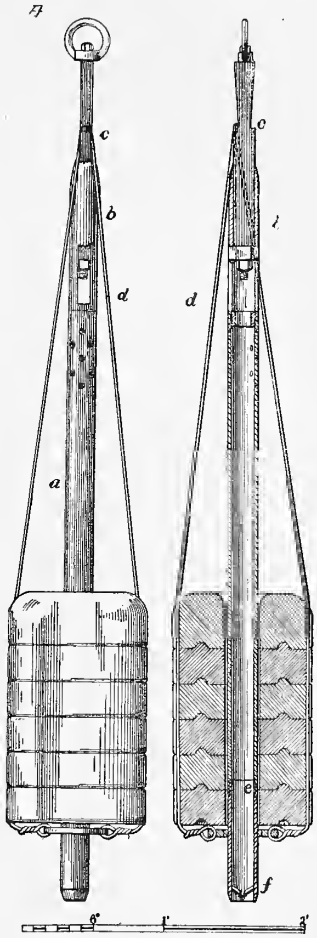


THE BELKNAP SOUNDING CYLINDER, NO. 2.

a. Cylinder, brass.
b. Castings, brass.
c. Screw connection of cylinder to casting.
d. Upper valve seat.
e. Lower valve seat.
f. Upper valve.
g. Lower valve.
h. Poppet valve.
k. Spiral spring.
l. Shoulder holding lower valve seat down.
m. Rod, iron.
n. Detacher, iron.
o. Swivel ring, iron.
p. Screw connection of rod to casting.
q. Stud, brass.

H. B. M. S. *Challenger* sailed on her celebrated scientific voyage around the world in December, 1872, six months after the introduction of Sir William Thomson's machine for sounding with wire, and at the instance of the inventor one of his machines was placed on board, but was relegated to the storeroom, where it remained during the entire cruise notwithstanding the remarkable success attending its introduction into the United States Navy and Coast Survey.

The successful operations of the *Porcupine* in sounding with rope naturally influenced its retention on the *Challenger*, which was amply supplied with the best Italian hemp No. 1 line, 1 inch in circumference, weighing about 200 pounds per nautical mile. The Baillie sounding machine, a modification of the Hydra, was adopted, and it was unquestionably the best device yet introduced for sounding with rope. It differed from the Hydra principally in the detacher, which was much improved; the rod remained practically the same, and the disk weights were retained. A further increase in the weight of sinkers to 400 pounds and upward in deep water, enabled them to obtain good results, although at the expense of much time and labor.



CUT 28.—Baillie sounding machine.

The Baillie sounding machine is described as follows by Sir C. Wyville Thomson:

It is represented in perfection in the position in which it is let go in A, and in section in same position at B. The tube A is about 5 feet 6 inches in length by $2\frac{1}{2}$ inches in diameter. The bore is 2 inches, so that the wall is one-fourth inch thick. The principal part of the tube is of iron. It is bored near its upper end with a number of holes to let out the water; it unscrews into two at *e*, and at its lower end, *f*, there is a pair of butterfly-valves working inward. A strong brass cylinder, *b*, with a diameter equal to that of the tube, is firmly attached to the upper end; a heavy piece of iron, *c*, works in the brass cylinder like a piston to the extent of the length of the slots, *d*, in the sides of the cylinder, in which it is retained by a strong square bolt. The piston iron is flattened, and it is provided at *c* with a projecting shoulder, which, when the piston is drawn out—the bolt being at the top of the slot as in the figure—is well above the top of the cylinder; but when the piston is drawn down, and the bolt at the bottom of the slot, the shoulder is just within the upper part of the cylinder. The wall of the upper part of the cylinder is beveled away to a long rounded slope.

When to be used, the instrument is hung by the ring to the sounding line, a sufficient number of weights are suspended on an iron wire sling, as in the Hydra machine, the tube passing through the middle of them, and the sling hooking upon the shoulder of the piston iron. When the tube and weights touch the bottom, the brass cylinder is pushed upward the length of the slots, and the sling is slipped off the shoulder of the piston iron by the upper rim of the cylinder and allowed to slide down over its beveled upper end. This is a very simple plan, and the doing away with the steel spring of the Hydra is an advantage. The larger tube also brings up a better and fuller sample of the bottom.

In the spring of 1873, a few months after the departure of the *Challenger*, the U. S. S. *Tuscarora*, Capt. George E. Belknap, United States Navy, was fitted out for the purpose of sounding a submarine cable route from California to Japan. She was

supplied with a large quantity of rope, steam reel, and other appurtenances, and, in addition, one of Sir William Thomson's machines for sounding with wire. It was furnished by order of Commodore Ammen, chief of the Bureau of Navigation, who rightly appreciated the great value of Sir William's invention, in spite of the crude and imperfect form of the original machine and the cold reception given it by the *Challenger*. He was familiar with Thomson's experiments, thoroughly understood the preeminent qualities of pianoforte wire for deep-sea sounding, and wisely trusted to Belknap's enterprise and inventive genius to supply any deficiencies that experience might develop in existing appliances.

Brooke's apparatus was designed for use with rope, as were all devices known at the time, and the production of a simple form of sounding rod and detacher fulfilling modern requirements was one of the first and most important problems Belknap had to solve. He retained the Brooke principle, modified the detacher very slightly to better adapt it for use with wire, increased the capacity of the cup or cylinder in order to bring up a larger bottom specimen, substituted a metal poppet-valve in place of the goose quills, provided for a free circulation of water through the cylinder during its descent, and protected the bottom specimen from wash during the ascent. It was introduced by the inventor as the Belknap deep-sea sounding cylinder No. 2, was successfully used throughout the extended cruise of the *Tuscarora*, and became the standard sounding cylinder for deep-sea work in the United States Navy and the Coast Survey.

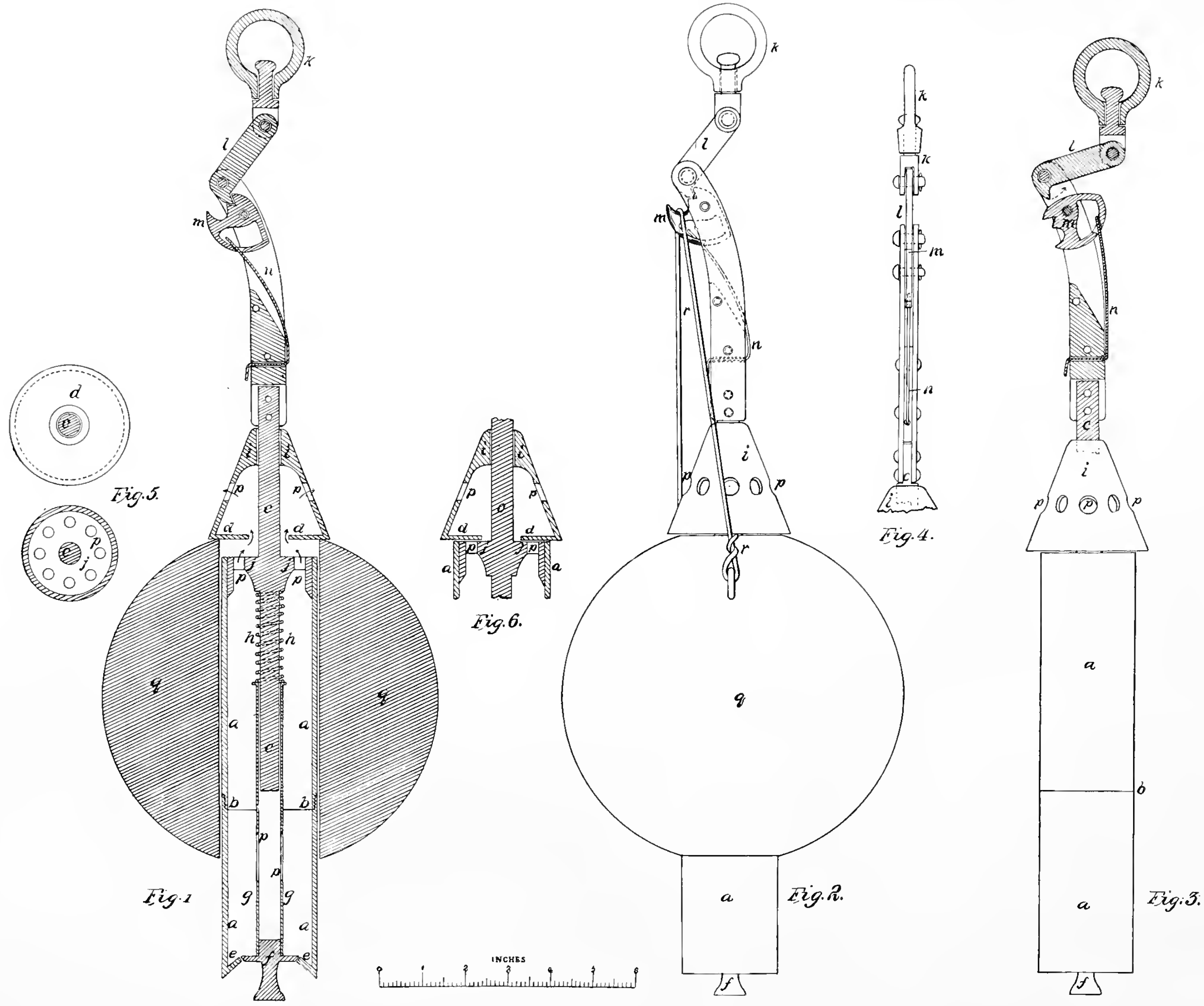
THE BELKNAP DEEP-SEA SOUNDING CYLINDER NO. 2.

The cylinder, casting, valves, and valve seats are brass, the rod and detacher of wrought iron or steel (plate XV). The detacher is so proportioned that the lip receives the wire bail and carries the weight of the sinker in exact prolongation of the axis of the cylinder, thereby maintaining it in a vertical position until the tension is removed by the sinker resting on the bottom; the wire is then slackened, allowing the detacher to fall by its own gravity, slipping the wire bail and releasing the weight, which has carried the cylinder swiftly down and pressed it into the bottom soil to receive its specimen.

The cylindrical casting has a screw at its upper extremity by which the rod is attached. The upper cylinder head and valve seat are formed by an expansion of the casting near its center, and a small shoulder a few inches beneath it holds the lower valve seat in place. The spiral spring and poppet-valve stem are contained within a cylindrical chamber which serves as guide for both.

The upper and lower valves have free vertical movement; they are faced with leather to insure their being tight, and the valve seats are provided with apertures for the free circulation of water during the descent, when the valves are all kept open by the upward rush of water through the cylinder, and promptly closed by reverse action when the upward movement begins, thereby preventing the wash of the bottom specimen in the barrel of the cylinder.

The spiral spring is delicately adjusted to retain the poppet valve on its seat without undue resistance to external pressure, and the adjustable screw stud projecting below the cylinder is intended to facilitate the opening of the poppet valve, and is of service only on hard, sandy bottom. The bottom specimen is removed by unscrewing the cylinder from the casting at *c*.



Nomenclature.

a. Cylinder.
b. Screw joint.
c. Upper and lower guide stem.
d. Cylindrical ring.
e. Valve seat.
f. Poppet valve.
g. Valve stem.
h. Spiral valve spring.
i. Hollow cone.
j. Perforated plate.
k. Swivel.
l. Pawl.
m. Tumbler.
n. Spring.
p. Apertures for escape of water.
q. Sinker.
r. Iron wire bail.

THE SIGSBEE SOUNDING ROD.

FIG. 1. Longitudinal sectional elevation of the Sigsbee sounding rod.
FIG. 2. Side view, with the sinker suspended from the detacher by the wire bail.
FIG. 3. Plan view of the cylinder and a longitudinal sectional elevation of the detacher.
FIG. 4. Back view of the detacher.
FIG. 5. The perforated plate *j* and cylindrical ring *d*.
FIG. 6. Enlarged view of the hollow cone *i*, cylindrical ring *d*, apertures *p*, and the upper end of the cylinder *a*.

THE SIGSBEE SOUNDING-ROD.

The next marked improvement was made by Lieut. Commander C. D. Sigsbee, U. S. N., while in command of the United States Coast Survey steamer *Blake* from 1874 to 1879. Following in the footsteps of Belknap and conversant with his work on the *Tuscarora*, he was in a particularly favorable position to take up the general subject of improved appliances and methods in deep-sea sounding.

The *Blake* had a Thomson machine for sounding with wire, which Sigsbee used with great success in his extended examination of the Gulf of Mexico. The first of his many improvements in deep-sea apparatus was a detacher which he used in connection with Belknap's cylinder No. 3, followed by a design of his own, a modification of Belknap's No. 2, which after much experience he considered superior to the former for deep-sea work. Regarding this, Sigsbee says (Deep-Sea Sounding and Dredging):

The results of my experiments showed that a simple cylindrical pipe, open at both ends, could be plunged far into the sand, which, however, resisted the blunter forms to a degree that precluded their adoption. Here was a suggestion—to shape the specimen cup as nearly as possible like an open cylindrical pipe; to drive it into the bottom material, and to retain the inclosed specimen. Belknap's sounding cylinder No. 2 seemed to answer the demands better than anything else, the poppet-valve being, to my mind, preferable to the butterfly-valve which is sometimes used. Accordingly, cylinder No. 2 was modified by me in some respects, and fitted with the Sigsbee detacher, after which it was brought into service on board the *Blake*. The spring, the cone top, and the fittings for permitting the escape of water are changed somewhat from Captain Belknap's plan, but their operation is, in effect, about the same. It is not intended that this rod shall get a specimen of bottom water.

He enumerates the requirements for a perfect sounding-rod, as follows:

1. Certainty of not detaching the sinker during the descent.
2. Certainty of detaching on striking any character of bottom.
3. Certainty of not rehooking or of fouling with the sinker, in any way, after the same has once been tripped.
4. Adaptability to getting a specimen from the various kinds of bottom material.
5. Certainty of not grappling irretrievably with the bottom.
6. Certainty of retaining the specimen against the wash of water in the ascent.
7. Handiness for extracting the specimen and for cleaning the parts.
8. Freedom from changing its form under the severe pressure in deep water.
9. Strength, simplicity, cheapness, light weight, and freedom from corrosion.

In general there are two ways of detaching a sinker from its rod: (1) By actual or partial slacking of the sounding wire or rope. (2) Directly by the impact of the rod against the bottom. The former method is regarded as safer, but sometimes both are involved in one detaching apparatus. The detacher which depends for tripping solely on the resistance of the bottom material is usually more sensitive on hard than on soft bottom; also, should the sinker glance on the side of a rock or ledge the trigger or other appliance might not be presented fairly to the blow necessary to upset the connection which holds the sinker in place.

The action of the original detacher by Brooke was based on the elimination of the tension on the line. This is the principle applied in the Sigsbee detacher, and, indeed, in almost all others approved by persons of experience in deep-sea sounding.

Remarking upon the construction of the sounding-rod, he says:

1. The pawl and tumbler are made to fit each other in such a manner that, when connected and under strain, they are held undeviatingly as shown in figs. 1 and 2—that is, the wire is in the prolongation of the axis of the rod. If this be not observed the relation of the leverages of the pawl and tumbler will be destroyed and the detacher may be too sensitive, besides which the rod may incline to a degree that will act somewhat against a vertical descent.

2. That part of the lip of the tumbler on which the bail of the shot rests should have the edges beveled or rounded, otherwise the edges may be broken up and spread, thus preventing the tumbler from being thrown back between the side pieces. Thin washers put on either side of the tumbler and pawl would probably be an improvement.

3. All parts should work freely.

4. The bottom of the specimen cup should have the proper bevel; if too sharp it may retain but a small specimen, and if too blunt the rod may not penetrate firm material.

5. The spiral spring *h* should not be so strong as to prevent soft bottom material entering the cup; its strength should be sufficient, when the rod is lying flat, to force the valve smartly to its seat when the valve is pushed inward and released, and yet not strong enough to seat it by about 1 inch, when the rod is held bottom upwards. The springs for the *Blake's* rods are of No. 17 American, or No. 18 Stubb's gauge spring-brass wire; they are 3 inches in length when not under compression, and have twelve coils each. Any spring thus made could easily be adapted to the requirements.

6. If desired, the rod might be made considerably lighter for very deep work, the present size of the detacher being retained. On the scale of plate XVI, the rod and detacher are strong and handy, weighing 5¼ pounds. The size of the specimen sought should have much influence in determining the size of the rod. If only an indication of the bottom material were wanted, no specimen for careful examination being needed, a rod weighing only 2 or 3 pounds would suffice.

DETAILS OF CONSTRUCTION.

The cylinder *a*, fig. 1, plate XVI, is a brass tube of commercial pattern, 2¼ inches outside diameter and 10 inches in length, rigidly secured to the perforated plate *j* by small brass screws, and the valve seat *e* is soldered to the other extremity of the cylinder which has its cutting edge sharply beveled as shown in fig. 1. The poppet-valve *f* is of cast brass secured by a drift-pin to its hollow stem, a thin brass tube, which impinges on the spiral spring *h*, both traversing the stem freely. The upper and lower guide stem is a brass casting enlarged near its center to form the perforated plate *j*. The hollow cone *i* is a brass casting having apertures, *p*, for the escape of water; the cylindrical ring *d* is soldered to its base.

The detacher is composed of the tumbler *m*, pawl *l*, swivel *k*, and spring *n*; all movable parts working on loose brass pins which are held in place by small split keys of spring brass. The spring is of No. 14 American gauge brass spring wire. The detacher frame is riveted to the flattened end of the guide stem, in prolongation of it, and there is a screw joint at *b*, on the cylinder, by which the two parts are separated for convenience in securing its contents.

TO USE THE SOUNDING-ROD.

To sound and bring up a specimen of the bottom, attach the stray line, which should always intervene between the wire and sounding rod, to the swivel ring *k*, pass the rod through the hole in the sinker, hook the wire bail *r* over the lip of the tumbler *m*, lock the pawl and tumbler and suspend the rod from the swivel ring *k*, when it will promptly assume a vertical position. The cone *i* remains unseated during its descent by contact with the shot (fig. 1), and the valve *f* is raised by the upward pressure of the water, which then circulates freely through the cylinder, reducing its resistance and increasing its rate of descent.

When the sinker strikes the bottom the tension on the line is relieved and it becomes more or less slackened, the pawl assumes a horizontal position by its own weight, releasing the tumbler, which is thrown out of action by the spring *n*, assisted by excess of weight at the lip, and thus the sinker is released.

The combined weight of shot, sounding-rod, small lead, and thermometer, altogether about 70 pounds, descending at the rate of 8 to 10 feet per second, forces the

rod well into ordinary soils, lifts the valve *f*, and fills the cylinder to a greater or less extent with a bottom specimen. The reverse motion, when the ascent begins, promptly closes the valves and protects the contents from wash, to which it would otherwise be subjected. The specimen is readily removed by disconnecting the cylinder at the screw joint *b*, which also facilitates the cleansing of the cup.

Failure to detach the sinker.—The Sigsbee sounding-rod has been used exclusively on the *Albatross* since 1882, except during the cable survey between California and the Hawaiian Islands, when a few No. 2 Belknap cylinders were received and successfully used from time to time, although the Sigsbee rod was preferred in deep water.

Several thousand soundings have been made with the latter on board the *Albatross* without a single failure to detach the shot and bring up a bottom specimen through any fault of the instrument itself. Failures from the following causes have occurred, however, at rare intervals:

1. The wire bail was too short and brought sufficient tension on the lip of the tumbler to sustain the weight of the pawl by friction of the latch surfaces, a rare occurrence, possible only through the determined effort of a muscular man.
2. It has failed to detach in deep water and very soft bottom, from the rod having been carelessly sent down with the spring *n* out of action.
3. The rod jammed in the shot by a pebble becoming detached from the scale in the hole, which had not been properly cleaned. The bail was free.
4. Partially disintegrated volcanic rock was driven into the space between rod and sinker so firmly that the shot was brought back although the bail was free.
5. The rod struck hard rock with sufficient force to bruise and distort the bottom to such an extent that it would not go through the hole in the sinker although the bail was free.
6. Once during a gale of wind, with heavy breaking sea, the descent of the stern of the vessel from crest to trough was so violent that it slackened the wire and detached the shot. It is remarkable that this should have been the only instance of the kind, for the *Albatross* sounded from the stern in all conditions of wind and weather.
7. An officer unaccustomed to sounding with wire allowed the reel to "run wild" until slack turns of wire were seen, and, supposing bottom had been reached, hove in the wire, bringing the sinker back from the few hundred fathoms that had run out.

Failures of the rod from any cause were so rare as to provoke comment when they did occur, and it was seldom those mentioned above happened more than once.

The Belknap cylinder No. 2 failed to detach its shot on a few occasions:

1. In deep water and very soft bottom it sometimes failed to detach promptly, but it was usually accomplished after repeated efforts, although on a few occasions the shot was brought back.
2. The rod and detacher unscrewed from the cylinder on one occasion and the latter was lost.
3. The shot was brought back with the bail over the detacher, which had fallen the wrong way when the wire slackened. It was caused doubtless by the shot landing on rough bottom and capsizing before it was detached.

The failures mentioned in connection with the Belknap cylinder No. 2 did not happen with the Sigsbee rod, but such as occurred with the latter are equally liable to happen with either.

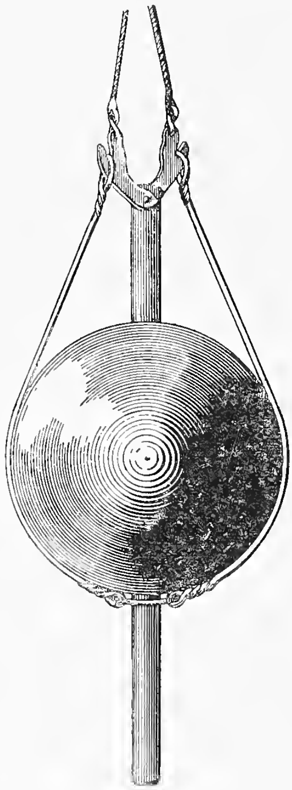
IMPROVISED SOUNDING-RODS.

It may be desirable at times to have a cheaper and lighter sounding-rod, in very deep water for instance, where small specimens are required, sufficient only to indicate that bottom has been reached, or the supply of rods may be exhausted by unexpected losses while at sea engaged in important work which would suffer from the delay incident to an immediate return to port. Hence any device, however crude, would be

of great value providing it insured uninterrupted continuance of operations, and it is hardly reasonable to suppose that a vessel conducting extensive deep-sea sounding would be without the necessary materials with which to construct some simple and fairly effective form of rod.

THE SIGSBEE GAS-PIPE SOUNDING-ROD.

In the deep waters of the Gulf of Mexico, where large bottom specimens were not required, Sigsbee used a sounding-rod of one-half-inch to three-fourths-inch gas pipe, 20 inches in length, with a Sigsbee detacher screwed into one end, and in the other a metal ball valve to retain a small bottom specimen; an arming of tallow may be used, but the valve is preferable. Additional length is given the cylinder to insure prompt action of the detacher when the shot reaches the bottom. A ball of lead or other metal inserted in the pipe with one-eighth-inch clearance and the lower end of the latter upset sufficiently to form a valve seat will answer the purpose; there should be a couple of small holes in the pipe near the upper end for the escape of air and water. This rod being inexpensive, light, and offering little resistance when reeling in, may be used to advantage under the exceptional circumstances before mentioned.



CUT 29.—The Brooke double-arm detacher.

EMERGENCY SOUNDING-RODS.

Sounding-rods of this description would be used only when the regular supply became exhausted, and, being hurriedly improvised, perfect action or thorough reliability could not be expected. They may be made of iron or brass pipes, spare condenser tubes, iron rods, or flat bars, providing they have the necessary rigidity. The gas-pipe rod has been described, and if the facilities are at hand for making the Sigsbee detacher an effective sounding-rod is assured, otherwise there is left a choice between the two forms of Brooke apparatus, the double and single arm detachers.

THE BROOKE DOUBLE-ARMED DETACHER.

While this form is not as readily operated or as reliable as the single arm subsequently introduced by Brooke and generally adopted, it is the most readily improvised with the facilities usually found on shipboard, and deserves a short description.

It is composed of two flat arms, alike in every respect, each having a hole through its lower end for a pin upon which they work, a hole through their upper extremities to which the bridle is attached, and lips on their outer edges from which to suspend the sinker during its descent and release it when it strikes bottom.

The single arm detacher has already been described with the Brooke deep-sea sounding apparatus. Belknap adopted it, and next to the Sigsbee it is the most reliable. Its construction is comparatively simple, providing the points of suspension are maintained in prolongation of the axis of the rod, as shown in the description of

the Brooke apparatus, and it would probably be the form usually adopted. To insure proper action the relative proportions of the detacher would be determined by experiment, and if it be made to release the weight at a tension of 10 pounds and hold on to it under greater strain it can not be far wrong. The Sigsbee detacher trips at 8 pounds, but it would not be advisable to give an improvised tumbler so small a margin of safety.

IMPROVISED BROOKE SOUNDING-ROD.

Sigsbee's gas-pipe rod with Brooke's single detacher is the simplest and most effective, providing suitable pipe is at hand; if not, an iron rod may be substituted, the upper end split to admit the detacher, and a short piece of pipe attached to the lower end for a specimen cup, substituting the ball valve for the goose quills of Brooke's rod. If pipe can not be had, a small chamber can be formed by drilling, in which an indication of bottom may be obtained by coating the interior with white paint.

THE BAR SOUNDING-ROD.

In the absence of other material a serviceable sounding-rod may be improvised by taking two pieces of flat bar-iron, from 1 inch to 1½ inches wide and 2 feet long, and inserting between them three filling pieces cut from the same bar, placed at irregular intervals as follows: One at the bottom, one 4 inches above it, and the other 6 inches below the detacher; drill or punch corresponding holes through bars and filling pieces and rivet them together; smooth the outer surfaces to insure free passage through the hole in the sinker and adjust the detacher, the bars having been shaped for the purpose. The interior space between the lower filling pieces, being coated with thick white paint, will serve as a specimen cup.

LEADS AND OTHER WEIGHTS FOR SOUNDING.

The time-honored lead, so familiar to all mariners as the medium of communication between the surface and bottom by sounding, retains its place to a great extent in shoal water, and even in moderate depths, but has been superseded for deep-sea work by modern appliances.

Hand leads, weighing 7 to 14 pounds, are used in shoal water and cast by one man.

Coasting leads vary in weight from 25 to 50 pounds. They are used in depths beyond the reach of the lighter hand lead, and usually when the vessel is under way; they are now frequently used in combination with wire and pneumatic sounders for navigational purposes, and depths of 50 to 100 fathoms are readily reached while the vessel is at full speed. The general introduction of wire for deep-sea sounding has increased its range and it is common practice to use it in depths not exceeding 1,000 fathoms where large bottom specimens are not required. A 35-pound lead is used for this purpose on board the *Albatross*.

Deep-sea leads range from 75 to 120 pounds in weight and are used for sounding in moderate depths, with rope; they are no longer in use on board vessels provided with wire for sounding.

The auxiliary lead, weighing about 4 pounds, is attached to the stray line whenever wire is used in sounding to prevent its kinking when the weight of sinker is suddenly removed by its striking the bottom.

The shape of leads is practically the same for all sizes; they are octagonal in cross-section, largest at the base, tapering gradually to the upper end, which is flattened and pierced with a hole through which the lead line is secured; and a roughened, irregular cup-shaped cavity is formed in the base for the reception of arming, which is usually of tallow, or a mixture of tallow and white lead.

Mechanical attachments, such as the Stellwagen and Sands cups, have been applied to coasting and deep-sea leads, and under favorable conditions bring up satisfactory bottom specimens, but their range being confined to depths within 1,000 fathoms, where liability to injury from contact with rocky or coral bottom is greatest, they have not come into general use.

DETACHABLE SINKERS.

The 60-pound spherical shot is the standard sinker in general use on board United States vessels for deep-sea work. It is about 8 inches in diameter, has a 2½-inch hole through its center, and small eyes or lugs of No. 5 American gauge iron wire are cast upon opposite sides of its upper exterior surface, to which the ends of the bail are secured. Sinkers of greater weight have been recommended, and, while the necessity for increased weights has not been felt on board the *Albatross*, where the 60-pound shot has been in constant use, under all conditions of service, up to depths exceeding 4,000 fathoms, it is possible that in exceptionally deep water, where the weight of wire largely exceeds that of the standard sinker, or when from any cause the wire can not be maintained in a vertical position, a 75 or even an 80 pound weight may be used to advantage. It must be considered, however, that the wear and tear and liability to accident increases with the size of the sinker.

In sounding with rope of large cross-section, which is peculiarly susceptible to the deflective force of currents, the preponderance of weight should be largely on the side of the sinker, while the expert sounder with wire cares little on which side it is.

Experience on the *Albatross* led to the adoption of a lighter detachable sinker, which has been used to advantage between 1,000 and 2,000 fathoms, and occasionally in still greater depths; once, at least, a sounding was taken with it in over 3,000 fathoms.

The 35-pound sinker is of cast iron, elliptical in form, 8 inches in length, 5¾ inches in diameter, with a 2½-inch hole through the center; the wire lugs described in connection with the 60-pound shot are common to both.

The advantages attending the use of the lighter sinker within prescribed limits are the facility of manipulation, the minimum of wear and tear on sounding machine and wire, and economy of material. The disadvantages are nominal when operating in smooth water, but in a heavy sea the loss of time becomes apparent and frequently of sufficient moment to warrant the use of the heavy weight.

Sinkers are usually made of scrap iron, and cost from 2½ to 3 cents per pound.

IMPROVISED DETACHABLE SINKERS.

Sinkers of the ordinary type are comparatively inexpensive and easily stowed on board ship, hence a sufficient supply is usually carried to meet all possible contingencies; yet it has been found necessary to resort to makeshifts rather than suffer the loss of time and extra expense of an immediate return to port. Sigsbee sounded successfully in the Gulf of Mexico with a gas-pipe sounding rod and old grate bars,

an old ash bucket filled with fire brick, etc., and the list of available material may be largely extended.

If old lead can be had, it would be very easy to cast disks weighing from 10 to 20 pounds, which may be used in series, as on the Baillie machine. In the absence of better facilities they may be cast in open molds of ordinary deck sand; a little molasses and flour should be added to give greater consistency, wood or metal being used for a core.

Cast-iron ballast is readily transformed into sinkers; shot, shell, and canister are equally available; and small chain or wire rigging made up in suitable coils, chain shackles, and pins, links of chain cable, pieces of condemned machinery, and even sand in tin cans or canvas bags may be utilized. Wire is preferable to hemp or manila for binding fragments together to form a well-balanced sinker, and it is best for bails also.

LUGS AND OTHER DEVICES FOR SUSPENDING DETACHABLE SINKERS.

The lugs on detachable sinkers reached their present form through a process of evolution. Brooke suspended the shot by slings and washer, as shown with his apparatus, and Belknap used the same until repeated fouling of washer and cylinder induced him to substitute wire slings, which consisted of two rings surrounding the upper and lower quarters of the shot held in place by cross-seizings and two wire lanyards, one end secured to the lower ring on the sinker, and on the other end small iron rings to receive the lip of the tumbler and insure prompt clearance when it tripped. This arrangement prevented fouling, but was found to be rather cumbersome and required too much time to prepare the sinker for use.

Cast-iron lugs on the upper exterior surface of the shot were soon adopted, and proved to be a long stride in the direction of simplicity, certainty of action, and immunity from fouling. A single wire bail was used, the ends being secured to the lugs with large eyes, which permitted it to move freely and even fall away from the disengaged tumbler by its own weight. The sole disadvantage attending the introduction of cast-iron lugs was the frequent breakages caused by the brittleness of the material.

Bail holes were introduced by Sigsbee, who found cast-iron lugs too unreliable. They were cast in the same relative positions on the surface of the sinker, which insured convenient and secure attachments for the bail but did not allow the same freedom of movement.

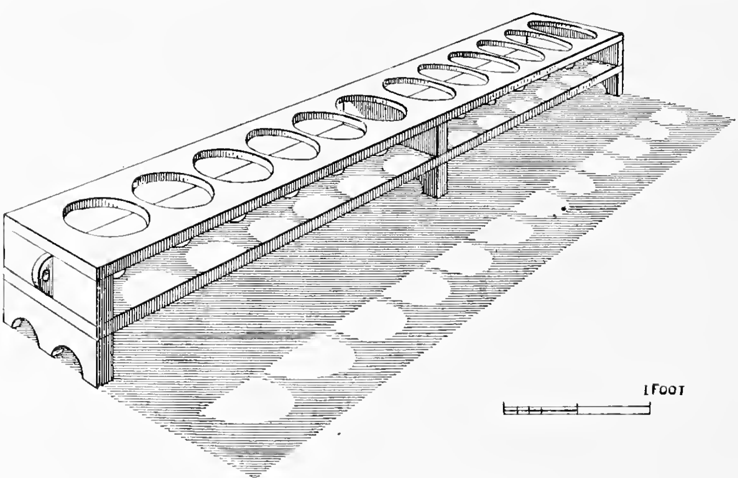
Iron wire lugs, cast with the shot, were subsequently introduced and are still in general use. They are in the form of wire staples, cast into the surface of the sinker parallel with the axis of the central hole, and project above the surface only far enough to afford convenient attachment and free movement of the bail. They are seldom broken by rough handling, as the wire becomes thoroughly annealed in the process of casting and subsequent cooling, and they can be bent flatly to the surface of the shot without injury.

The wire bails now used with detachable sinkers are of annealed iron wire, No. 8, American wire gauge, and may be conveniently fitted by first cutting them from the coil in uniform lengths and bending them over a form to insure a free and uniform seat for the lip of the tumbler.

Sinkers should not be bailed until they are required for use, and when the requisite number have been placed in the racks, proceed first to examine the lugs and

see them properly straightened, then pass the sounding rod back and forth through the hole, and when satisfied that it moves freely let it remain in the sinker with its weight resting on the base of the hollow cone; pass the ends of the bail through the lugs, put the bight over the tumbler, which for convenience has been placed in action and secured by a seizing of twine, then bend the ends up and take a couple of turns around their standing parts, leaving sufficient slack to unhook the bail without displacing the tumbler. This will insure the proper length of bail, which should suspend the shot just high enough to lift the hollow cone off its seat without bringing its apex in contact with the shoulder at the upper end of its stem. It is not absolutely necessary to hold the hollow cone off its seat during the descent, but by doing so the sinking of the shot is accelerated in proportion to the power required to lift it by the ascending column of water in the sounding rod.

Caution should be observed when fitting the bails that no projecting scraps of iron are left in or at either end of the hole and that all scale is removed from its walls, for it expands and becomes softened when it is wet; at the same time the material of the



CUT 30.—Rack for holding sinkers.

sinker shrinks under low temperatures near the bottom, both tending to crack and disengage the scale, which is liable to jam the sounding rod irretrievably.

Racks for sinkers are necessary on board of vessels engaged in extensive deep-sea exploration, not only for convenience in bailing and final preparation, but to have a sufficient number at hand for present use, and also to avoid the necessity of bringing them on deck and fitting them at night. They should be placed near the sounding machine and be capable of holding a dozen sinkers at least.

A serviceable rack can be made from two boards 1 inch thick and 12 inches wide, placed one above the other, 4 inches apart, and secured by suitable end and transverse pieces. The upper board has a series of circular holes that receive the sinkers and allow them to rest on the lower board, which is pierced with 3-inch holes, directly under the larger ones, to allow for the passage of the sounding rods, and, in order that they may be passed their whole length through the sinker, the rack should be 10 inches in height.

THE USE OF WIRE FOR SOUNDING.

The first recorded instance of wire having been used for deep-sea sounding was by the Wilkes Exploring Expedition, 1838–42. In 1849, Captain Barnett, H. B. M. S. *Thunderer*, experimented with it, and during the same year Lieut. J. C. Walsh, United States schooner *Taney*, attempted to sound with it in the vicinity of the Bermudas. It failed in every instance from practically the same causes, although Wilkes was unfortunate in the selection of copper wire which was of such low tensile strength that little margin of safety remained. Barnett used iron wire of large size and sufficient strength, while Walsh was supplied with three sizes of steel wire, either of which would have proved successful under proper treatment.

The principal causes of failure were due to insufficient weight of sinkers and lack of proper control over the reel when paying out, as evidenced by such time intervals as were recorded, which show a more rapid rate of descent than obtains in the best modern practice with perfected appliances and a proper relation of weight between the sinker and submerged wire. These repeated failures brought wire into such disrepute that no further attempts were made to sound with it until Sir William Thomson commenced his experiments in June, 1872, which resulted in totally revolutionizing the art of deep-sea sounding. Commander (now Rear-Admiral) George E. Belknap, U. S. S. *Tuscarora*, used pianoforte wire successfully in 1873–74. Commander (now Commodore) J. C. Howell, United States Coast and Geodetic Survey Steamer *Blake*, adopted it later in the same year, and Lieut. Commander (now Commander) C. D. Sigsbee, succeeding to the command, used it with great success from 1874 to 1878, by which time it had passed the experimental stage and been generally adopted for deep-sea work.

Wire was first used by the United States Fish Commission on board the *Fish Hawk*, Lieut. Z. L. Tanner, U. S. N., on the 6th of August, 1880; then on board the *Albatross*, Lieut. Commander Z. L. Tanner, which made her first sounding with wire on March 22, 1883, and it has since been in constant and successful use on board vessels of the Fish Commission.

Sir William Thomson used pianoforte wire of No. 22 Birmingham wire gauge in his experiments and that size, or sizes closely approximating to it, have been universally adopted for deep-sea sounding.

The wire in general use for that purpose on board the *Albatross* is made by the Washburn & Moen Manufacturing Company, of Worcester, Mass., and called by them No. 11 music. It is 0.028 of an inch in diameter, weighs 13 pounds per nautical mile of 1,000 fathoms in air, 11.3 pounds in sea water, and approximates to No. 21 American gauge and No. 22 Birmingham wire gauge. Its tensile strength is remarkably uniform, the mean of many tests giving 207 pounds as the breaking strain; it is highly polished and resists rust unusually well when in use. It is furnished by the manufacturers in sealed tin cans, containing 50 pounds, or about 3,850 fathoms, in six coils 8½ inches in diameter, each coil being composed of two pieces of wire. It will be furnished in any desired length, however, on special order.

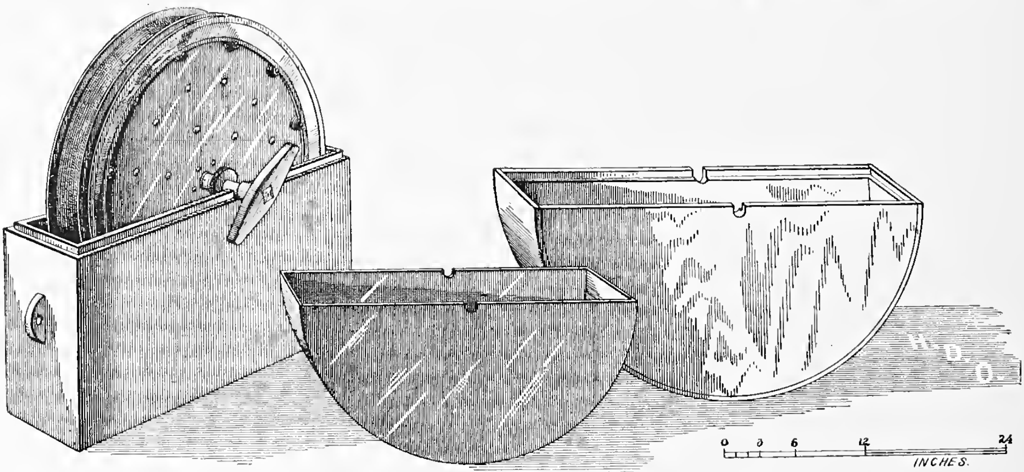
The coils are doubled for packing, one being laid on top of the other and carefully wrapped with the best oiled paper, a liberal sprinkling of whiting, slacked lime, or other absorbent being inclosed with the wire as a preservative against oxidation. The packages are placed one above the other in the can, a quantity of whiting between them, and sealed air-tight; the wire is practically indestructible so long as it remains in the sealed can, and, if stored in a dry place, will keep quite well in its paper wrappings after the can has been opened.

The *Albatross* has never lost a fathom of American wire from rust in the coil. English wire, No. 22 Birmingham gauge, has been used occasionally. Its tensile strength was 214 pounds, practically the same as No. 11 music, but it was not as highly polished as the American wire, and its only protection was an insufficient wrapping of oiled paper, which was liable to be torn in handling, thus exposing it to the action of sea air or other moisture, which soon caused it to rust. Losses from this cause were quite serious and tended to counteract the advantages derived from its cheapness at first cost. It was received from the makers, Messrs. Webster & Horsfall, Birmingham, England, in 18-inch coils, made up of pieces from 100 to 400 fathoms in length, the coils weighing about 60 pounds each.

An excellent quality of American wire, No. 21 gauge, was furnished to the United States Navy in 1892 by the John S. Roebling's Sons Co., of Trenton, New Jersey. Its tensile strength ranged from 245 to 255 pounds, and it was fairly well polished. It was slightly larger in cross-section than No. 11 music, which accounts in part for its greater strength.

PRESERVATION OF SOUNDING WIRE.

It should be received on board in sealed tin cans, which may be advantageously coated with paint before they are placed in the storeroom. Broken packages are liable



Cut 31.—Spare sounding wire, reel box, and copper tank.

to rust, hence as few as possible should be kept on hand. They may be stored for a short time with comparative safety, providing the wrapping is intact and the store-room perfectly dry. A safer plan is to submerge all broken packages in sperm oil.

The following method was finally adopted on board the *Albatross:* There were available two service reels, one temperature reel, and one storage reel, each holding nearly 6,000 fathoms of wire. Both service reels were kept ready for use, with about 5,000 fathoms of wire and stray lines attached. When unmounted they were submerged in sperm oil in suitable galvanized-iron tanks with tight covers. When mounted, but not actually employed in sounding, the lower part of the reel was submerged in sperm oil contained in a semicircular copper tank (cut 31) placed temporarily beneath it, and the oil was distributed over the surface of the wire by slowly revolving the reel a few turns once a day.

When actually engaged in sounding, the surface of the wire on the reel was

constantly oiled with rag or sponge while reeling in, and it was wiped with an oily rag when the intervals between casts exceeded twelve hours.

The temperature reel, with its special wire of large size, and the storage reel, filled with its sounding wire in readiness to be transferred to the service drums, were suspended upon their bearings in wooden reel boxes (cut 31) containing semicircular copper tanks, like that above described, with sufficient oil to submerge the lower portion of the reels, distribution of oil over the surface of the wire being effected by a few turns of the reels daily as before. The boxes have semicircular covers for the further protection of reels and wire.

Lime water has been successfully used as a preservative, but it is inferior to sperm oil for the purpose, and has the further disadvantage of irritating the eyes and aggravating any sores the sounding crew may have on their hands or faces, although this objection is hardly worthy of serious consideration except when sounding continuously.

Large, strong wire, No. 21 music, approximating to No. 18½ Birmingham gauge or No. 17 American gauge, is used on the Tanner machine, and little or no attention is given to its protection, except that new wire is imbedded in melted tallow when it is wound on the reel, and once or twice a year it is reeled off, cleaned with emery paper, replaced upon the reel, and again imbedded in melted tallow. The life of the wire under this treatment is about two years.

METHODS OF SPLICING WIRE.

Sir William Thomson describes his method in 1872 as follows:

> A splice 2 feet long I have found quite sufficient, but 3 feet may be safer. The two pieces of wire are first prepared by warming them slightly and melting on a coating of marine glue to promote surface friction. About 3 feet of the ends so prepared are laid together and held between the finger and thumb at the middle of the portions thus overlapping. Then the free foot and a half of wire on one side is bent close around the other in a long spiral, with a lay of about one turn per inch, and the same is done for the free foot and a half on the other side. The ends are then served round firmly with twine, and the splice is complete.

This splice is no longer used, and is given here simply as a matter of interest in connection with Sir William's successful experiments in sounding with wire.

BELKNAP'S SPLICE.

Commander George E. Belknap, U. S. N., adopted the following splice in 1873:

> A long-jawed twist, 2 feet in length, soldered at the ends and at two or three intermediate places, and served with fine waxed twine.

HOWELL'S SPLICE.

Commander J. C. Howell, U. S. N., used the following splice in 1874:

> A short-jawed twist, total length of splice 3 inches. After the first cross the turns are close together around standing part, the whole covered with solder, surface smoothed, and ends tapered.

This splice was successfully used by Sigsbee during his extended exploration of the Gulf of Mexico from 1874 to 1878.

THE ALBATROSS SPLICE.

This splice was reliable when new, but was liable to strip after extended wear. It was named from its having been the one adopted on board the *Albatross* in 1883, and is as follows:

> The ends of the wire, being first cleaned for 3 feet or more, are lapped and twisted together with eight long-jawed turns. The ends and two intermediate points are wound with a few turns of fine annealed iron wire, the whole covered with solder, ends tapered, and surface carefully smoothed.

MAY'S SPLICE.

Lieut. Sidney H. May, U. S. N., had charge of the *Albatross's* sounding apparatus during the first year of the cruise, and among many useful suggestions was the following wire splice (plate XVII), which proved so simple and effective that it was finally adopted in preference to all others. It is from 6 to 7 inches in length, will not strip, is quite flexible, and practically indestructible. The following describes the process:

Grasp the wire in a hand vice, lay the end on the soldering board or other convenient place, and taper it to a fine point with a three-cornered saw file; prepare the other end in the same way, lap them, put on the first annealed wire seizing, leaving the tapered end free; then take four turns with the free end and clap on the other seizing; pass the tapered ends snugly around their respective standing parts, using the pliers for the purpose.

Now apply the soldering fluid and cover the splice with solder by drawing it back and forth through molten solder contained in the grooved soldering board; then taper the ends and trim the surface with knife, file, and sandpaper.

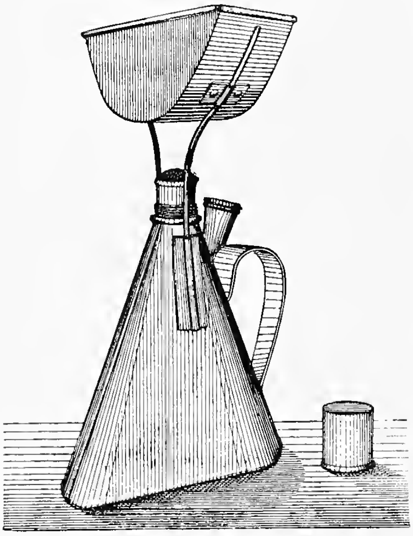
IMPLEMENTS REQUIRED.

The following implements are required for splicing wire:

1 tinman's furnace.	1 bottle soldering fluid.
2 soldering irons.	1 soldering board.
1 pair cutting pliers.	1 small bottle of oil.
1 pair small flat pliers.	1 small box of tallow.
1 small hand vise for holding wire.	1 canvas pocket.
1 spool of fine annealed iron wire.	1 soldering lamp.
1 box of soft solder.	

The splicing board is of hard wood, 1 inch thick, 6 inches wide, and 2 feet in length; a groove is cut across its surface, near one end, large enough to hold sufficient molten solder for one splice.

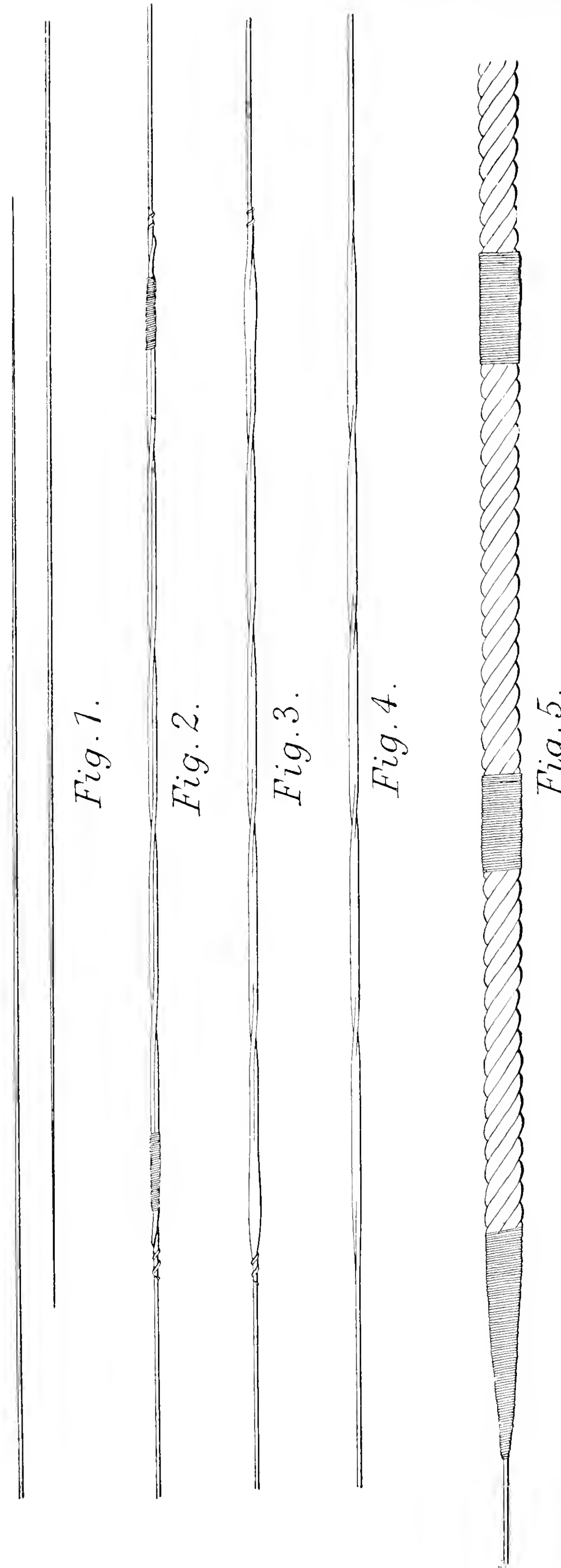
The canvas pocket is the most convenient receptacle for the splicing tools; it is provided with suitable compartments for each article, and is rolled up snugly and lashed when not in use.



CUT 32.—Soldering lamp.

The soldering lamp will be found convenient in calm, smooth weather; it is an ordinary alcohol lamp, with a large, round wick and an adjustable semicircular cup supported above the flame, in which the solder is placed and kept in a molten state as long as required. The wire, having been prepared as directed, is drawn back and forth through the solder until a sufficient quantity adheres to the splice, when it is trimmed and smoothed in the usual manner.

The soldering irons may be heated in the fire room or galley range in case a single splice is to be made, and one iron will suffice in the hands of an expert, yet any delay, however small, will make it necessary to use a second one. Almost any form of soldering iron will answer equally well when used with the soldering board, and it is not necessary that the points of the iron should be tinned.



MAY'S SPLICE.

Fig. 1. Tapered ends of the wire, full size.
Fig. 2. Ends laid together and seizings on.
Fig. 3. Splice partially covered with solder.
Fig. 4. The completed splice.
Fig. 5. Splice of sounding wire to stray line.

Soldering fluid, for use with soft solder, after Haswell's receipt, has been successfully used on board the *Albatross*, and is considered the best preparation for wire soldering. It is as follows:

To two fluid ounces of muriatic acid, add small pieces of zinc until bubbles cease to rise. Add half a teaspoonfull of sal ammoniac and two fluid ounces of water.

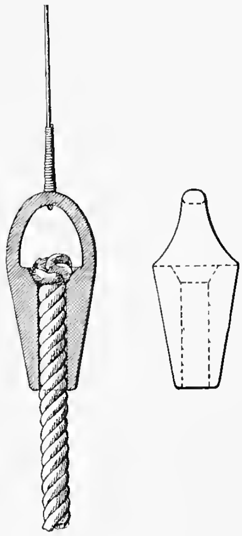
Pulverized resin may be used in the absence of soldering fluid, but greater care will be required in making the splice, and the results are liable to be unsatisfactory, particularly when splicing old wire.

METHOD OF SPLICING WIRE TO STRAY LINE.

In sounding with wire it is customary to splice about 5 fathoms of slack-laid cod-line to its working end to take up the slack that occurs when the sinker strikes bottom, and as a convenience for attaching the sounding rod, deep-sea thermometers, and auxiliary lead. This cord is known as the stray line and is attached to the wire in the following manner:

At a point about 5 inches from one end of the stray line stick the wire twice against the lay, fig. 5, then pass it with the lay from 4 to 6 inches, and again stick it twice against the lay. Cut the wire to the proper length, clap a seizing of waxed twine over the places where it was stuck against the lay, carefully covering the end of the wire to prevent its catching when reeling in. It now remains to complete the end of the splice: Put wire and stray line under moderate tension, lay the wire in the center of the line by passing the free end of the latter around it, put on a temporary seizing, trim the strands down to a point and serve over the taper with waxed twine. This makes a neat and secure splice which outlasts the stray line and reels in without danger of catching on guards or fairleader.

Tanner's link was devised by the writer as a simple method of quickly attaching wire and stray line in case either should break while sounding, thereby saving the time required to make the regular splice. It consists of a small brass link, through the socket of which the stray line is drawn and is held in place by a single wall knot, leaving the opposite end free for attaching the wire. A stray line fitted in this manner is adjusted in a moment by taking three turns of the wire around the link, and passing the end closely around its standing part half a dozen times. Attention will be required in reeling in to guard against the link fouling when it reaches the machine, but with ordinary care it may be used until such time as a regular splice can be made without loss of time.



Cut 33.—The Tanner link.

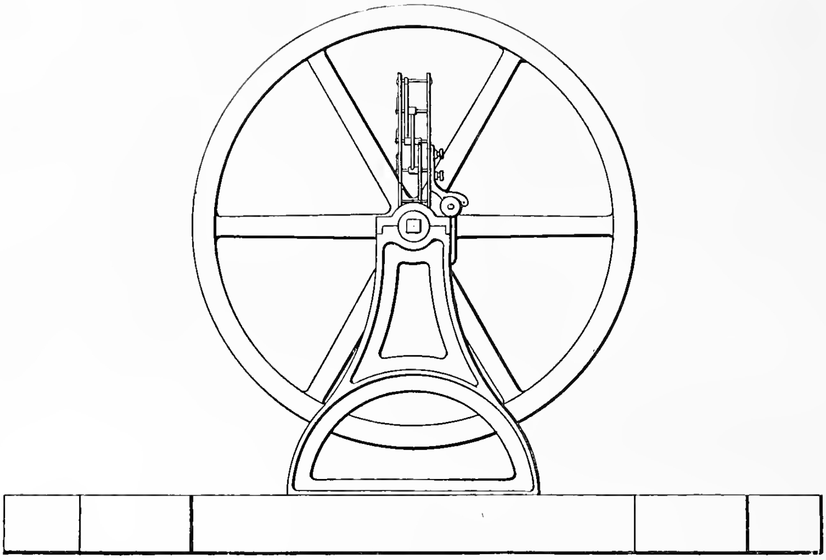
THE MEASURING REEL.

The service reel being 22.89 inches in diameter, the initial layer of wire, 0.028 inch in diameter, equals one fathom to the turn, the next layer a trifle more, and so on, until with a full reel the error would be about 10 inches to the turn; and as the register indicates the turns only, a correction must be applied to its reading. In order to determine the amount of error, the wire is measured as it is wound on the service reel by means of the measuring reel (cut 34), which is made

of cast iron, is 22.89 inches in diameter, and mounted in a cast-steel frame bolted to a heavy oak bed plate. On the reel shaft between the reel and frame is a worm wheel which actuates the register.

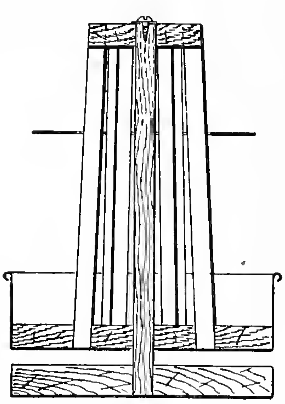
THE BLADE.

The blade is used in connection with the measuring reel for transferring wire from

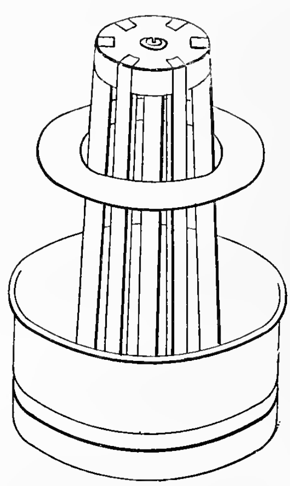


Cut 34.—Measuring reel.

the commercial coil to the service reel of the sounding machine. Cut 35 is a sectional elevation, and Cut 36 a general view of the blade used with American wire. It is



Cut 35.



Cut 36.

made of oak, has an iron screw and washer at the top of the spindle to hold the reel in place, a galvanized-iron disk that slips over the reel above the coil of wire to prevent

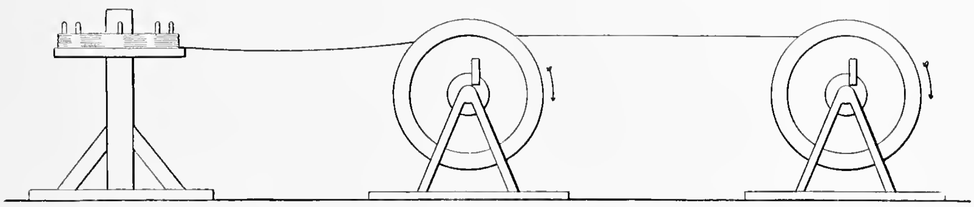
slack turns from flying off, and a galvanized-iron base rim around the reel to retain slack turns that slip down from the coil.

Cut 37 is a general view of the blade used with English wire, which is put up in larger coils than the American. It is constructed entirely of oak or other hard wood, and is adjustable by means of a series of holes through the disk into which pegs are set. The transfer of wire will be greatly facilitated by securing the blade to the deck during the operation by the means of screws, socket bolts, or other convenient method.

TRANSFERRING AND MEASURING WIRE.

The service reel is mounted on its machine, its face cleaned and oiled, hand cranks and register are shipped, and the latter carefully oiled and examined to see that it works properly.

The measuring reel is placed directly in the rear of the sounding machine, and the blade in the rear of the reel and in line with both. The sealed tin can in which the wire is received is opened, a coil taken out, removed from the paper, and placed on the blade; the wire stops are cut, the free end of the wire led out, and three turns taken around the measuring reel in such a manner that the register will count ahead during the transfer. The end is then taken to the service reel, and clinched through



Cut 37.—Measuring and transferring wire.

the hole provided for this purpose. The two men at the blade reel back the slack wire, the recorder sets both registers at zero, and takes his station for reading the one on the measuring reel, the officer in charge watching that on the service reel. The cranks are manned and the transfer begins, the reel being turned at any desired speed. One of the men at the blade puts a tension on the wire by pressing his hand against the side of the blade.

The recorder calls out "mark!" at every 50 fathoms registered by the measuring reel, the officer in charge reads the register on the service reel at the same instant, and this being recorded the difference between the two readings shows the error at that point. This process being carried on until the reel is filled, furnishes data from which a correction table is made, by which soundings can be corrected readily by inspection.

A correction table is always available for the same reel or any other of like dimensions, provided the wire is the same size and the amount does not exceed that for which the table was constructed.

The necessary data having been obtained as above described, it is advisable to construct a correction curve, frame it under glass, and hang it in some convenient

place to serve as a check on the table that is usually copied into the record book for daily use at the sounding machine; it will also furnish a graphic method of detecting errors in the computation and application of corrections taken from the table. The following figures are taken from the original record of the measuring and transfer of 4,577 fathoms of wire from the commercial coil to the service reel of the Sigsbee sounding machine on board the *Albatross*, and demonstrates, through the regular increase in the column of differences, the remarkable accuracy attainable by an expert in guiding wire evenly upon the reel, besides furnishing complete data for the construction of correction curve or table.

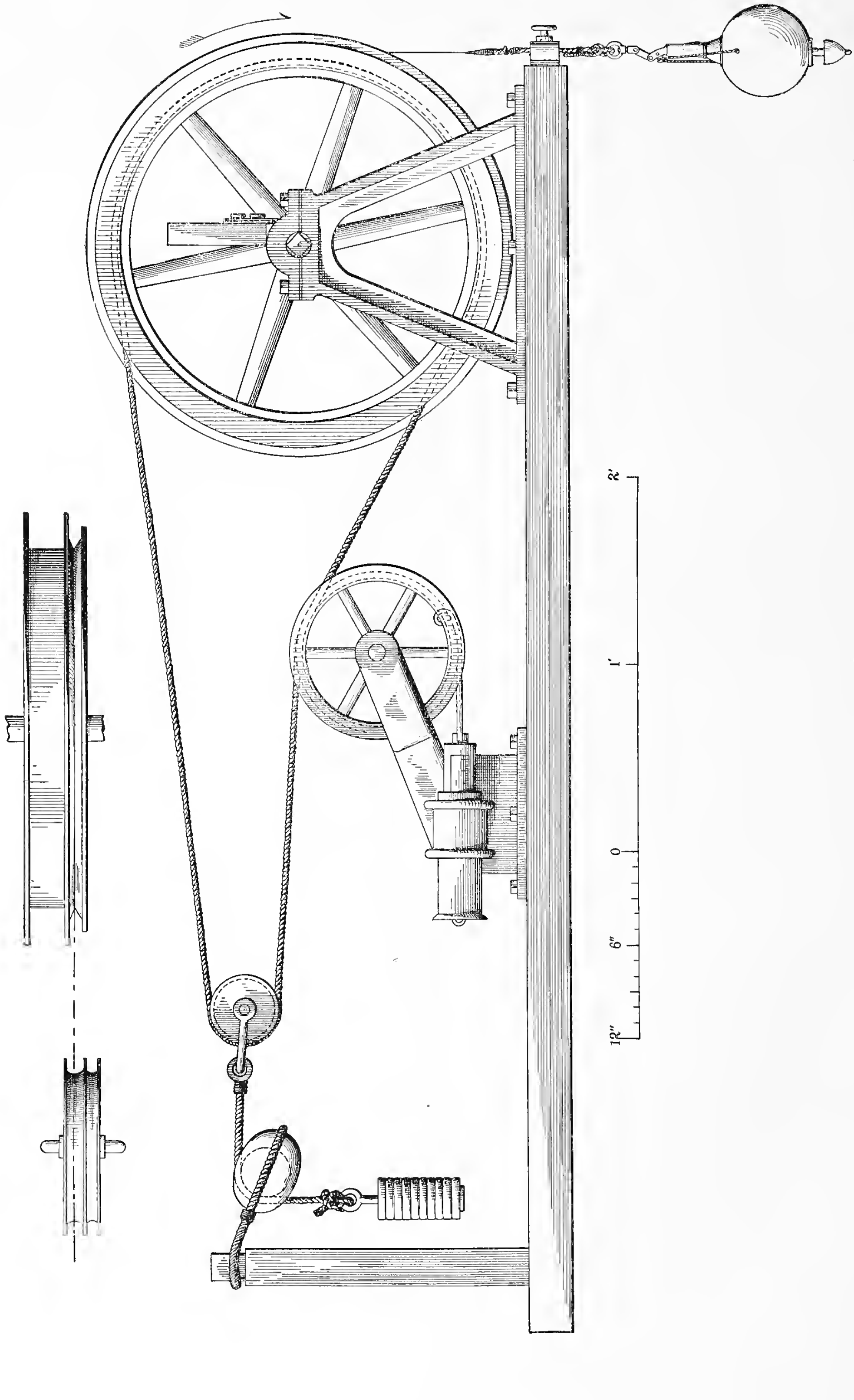
[Correction table, Navy steel reel, No. 2. Wire, No. 11 music.]

Number of turns on service reel.	Number of fathoms by measuring reel.	Fathoms diff. +	Number of turns on service reel.	Number of fathoms by measuring reel.	Fathoms diff. +	Number of turns on service reel.	Number of fathoms by measuring reel.	Fathoms diff. +	Number of turns on service reel.	Number of fathoms by measuring reel.	Fathoms diff. +
50	50	0	50	1, 160	10	50	2, 295	45	50	3, 452	102
100	100	0	1, 200	1, 211	11	2, 300	2, 347	47	3, 400	3, 505	105
50	50	0	50	1, 262	12	50	2, 399	49	50	3, 558	108
200	200	0	1, 300	1, 313	13	2, 400	2, 451	51	3, 500	3, 611	111
50	50	0	50	1, 364	14	50	2, 503	53	50	3, 664	114
300	301	1	1, 400	1, 415	15	2, 500	2, 555	55	3, 600	3, 717	117
50	351	1	50	1, 466	16	50	2, 607	57	50	3, 770	120
400	401	1	1, 500	1, 517	17	2, 600	2, 659	59	3, 700	3, 823	123
50	451	1	50	1, 568	18	50	2, 711	61	50	3, 876	126
500	502	2	1, 600	1, 619	19	2, 700	2, 763	63	3, 800	3, 929	129
50	552	2	50	1, 671	21	50	2, 816	66	50	3, 983	133
600	602	2	1, 700	1, 723	23	2, 800	2, 869	69	3, 900	4, 037	137
50	652	2	50	1, 775	25	50	2, 922	72	50	4, 091	141
700	703	3	1, 800	1, 827	27	2, 900	2, 975	75	4, 000	4, 145	145
50	753	3	50	1, 879	29	50	3, 028	78	50	4, 199	149
800	804	4	1, 900	1, 931	31	3, 000	3, 081	81	4, 100	4, 253	153
50	854	4	50	1, 983	33	50	3, 134	84	50	4, 307	157
900	905	5	2, 000	2, 035	35	3, 100	3, 187	87	4, 200	4, 361	161
50	956	6	50	2, 087	37	50	3, 240	90	50	4, 415	165
1, 000	1, 007	7	2, 100	2, 139	39	3, 200	3, 293	93	4, 300	4, 469	169
50	1, 058	8	50	2, 191	41	50	3, 346	96	50	4, 523	173
1, 100	1, 109	9	2, 200	2, 243	43	3, 300	3, 399	99	4, 400	4, 577	177

Splices occur at the following intervals, in fathoms: 100 295 630 880 1210 1625 1970 2170 2475 2970 3275 3560 3670 3770 4230.

Example: A sounding is made, the register reading 3,050 turns. What is the depth in fathoms?

Number of turns on the reel	4, 400	cor. + 177
Number of turns registered	3, 050	
Turns remaining on reel	1, 350	cor. — 14
Correction for 3,050 turns		+ 163
Number of turns registered		3, 050
Depth in fathoms		3, 213



THE SIR WILLIAM THOMSON SOUNDING MACHINE, ORIGINAL FORM, FURNISHED TO THE BLAKE.

[Correction table. Tanner reel. Wire No. 21. Musie No. 17, A. W. G.]

Turns on Tanner reel.	Fathoms by measuring reel.	Correction, in fathoms.	Turns on Tanner reel.	Fathoms by measuring reel.	Correction, in fathoms.	Turns on Tanner reel.	Fathoms by measuring reel.	Correction, in fathoms.
25	25	0	25	227	2	25	432	7
50	50	0	50	252	2	50	458	8
75	75	0	75	278	3	75	484	9
100	101	1	300	303	3	500	510	10
25	126	1	25	329	4	25	536	11
50	151	1	50	354	4	50	562	12
75	176	1	75	380	5			
200	202	2	400	406	6			

The wire is in one piece, without splices, having been made to order by Washburn & Moen.

Example: A sounding is made, the register reading 425 turns. What is the depth in fathoms?

Number of turns on the reel	550	cor. + 12
Number of turns registered	425	
Turns remaining on reel	125	cor. — 1
Correction for 425 turns		+ 11
Number of turns registered		425
Depth in fathoms		436

SIR WILLIAM THOMSON'S MACHINE FOR SOUNDING WITH WIRE.

Plate XVIII showing the Thomson machine as it was used on board the *Blake* for one season and the description of its operation, the latter in the words of the inventor, are taken from Sigsbee's Deep-Sea Sounding and Dredging (page 54). It is shown here not only as the first successful apparatus for sounding with wire, but as a type of the simplest and most easily constructed sounding machine. Sir William describes the machine and its action as follows:

The wire is coiled on a large wheel (of very thin sheet-iron galvanized) which is made as light as possible, so that when the weight reaches the bottom the inertia of the wheel may not shoot the wire out so far as to let it coil on the bottom. The avoidance of such coiling of the wire on the bottom is the chief condition requisite to provide against the possibility of kinks, and for this reason a short piece of hemp line, about five fathoms in length, is interposed between the wire and the sounding weight, so that, although a little of the hemp line may coil on the bottom, the wire may be quite prevented from reaching the bottom.

A galvanized-iron ring of about half a pound weight is attached to the lower end of the wire, so as to form the coupling on the junction between the wire and the hemp line, and to keep the wire tight when the lead is on the bottom and the hemp line is slackened. The art of deep-sea sounding is to put such a resistance on the wheel as shall secure that the moment the weight reaches the bottom the wheel will stop. By the "moment" I mean within one second of time. Lightness of the wheel is necessary for this.

A measured resistance is applied systematically to the wheel, always more than enough to balance the weight of wire out. The only failure in deep-sea soundings with pianoforte wire hitherto made has been owing to neglect of this essential condition. The rule adopted in practice is to apply resistance, always exceeding by 10 pounds the weight of the wire out. Then the sinker being 34 pounds, we have 24 pounds weight left for a moving force. That, I have found, is amply sufficient to

give a very rapid descent—a descent so rapid that in the course of half an hour or fifty minutes the bottom will be reached at a depth of 2,000 or 3,000 fathoms. The person in charge watches a counter, and for every 250 fathoms (that is, every 250 turns of the wheel) he adds such weight to the break-cord as shall add 3 pounds to the force with which the sounding wheel resists the egress of the wire. That makes 12 pounds added to the break resistance for every 1,000 fathoms of wire run out. The weight of every 1,000 fathoms of the wire in the air is 14½ pounds. In water, therefore, the weight is about 12 pounds; so that if the weight is added at the rate I have indicated the rule stated will be fulfilled. So it is arranged that when the 34-pound weight reaches the bottom, instead of there being a pull or a moving force of 24 pounds on the wire tending to draw it through the water, there will suddenly come to be a resistance of 10 pounds against its motion. A slight running on of the wheel—one turn at the most—and the motion is stopped.

The sounding was made without a hitch of any kind, but the reel showed signs of weakness soon after he began reeling in the wire and the 34-pound weight of sinker, which is referred to by Sir William as follows:

After about 1,000 fathoms of wire had been got in the wheel began to show signs of distress. I then perceived for the first time (and I felt much ashamed that I had not perceived it sooner) that every turn of wire under a pull of 50 pounds must press the wheel on the two sides of any diameter with opposing forces of 100 pounds, and that, therefore, 2,240 turns, with an average pull on the wire of 50 pounds, must press the wheel together with a force of 100 tons or else something must give way. In fact, the wheel did give way, and its yielding went on to such an extent that when 500 fathoms of wire were still out the endless cord which had been used for hauling would no longer work on its groove.

Sir William realized the necessity for improvement and encouraged inventors to take it in hand. Captain Belknap, U. S. N., was the first to use it, practically, and he soon remedied its greatest fault by devising a reel capable of withstanding the enormous crushing strains incident to actual service. He was very careful at first about increasing the weight of reel, lest its greater inertia should destroy its usefulness, but he soon found that a few pounds more or less was a matter of indifference to the practiced marine surveyor. Improvements have been introduced from time to time in this and other countries, but the principle of the Thomson machine is invariably retained.

THE SIGSBEE MACHINE FOR SOUNDING WITH WIRE, AND ITS ACCESSORIES, AS USED ON BOARD THE ALBATROSS.

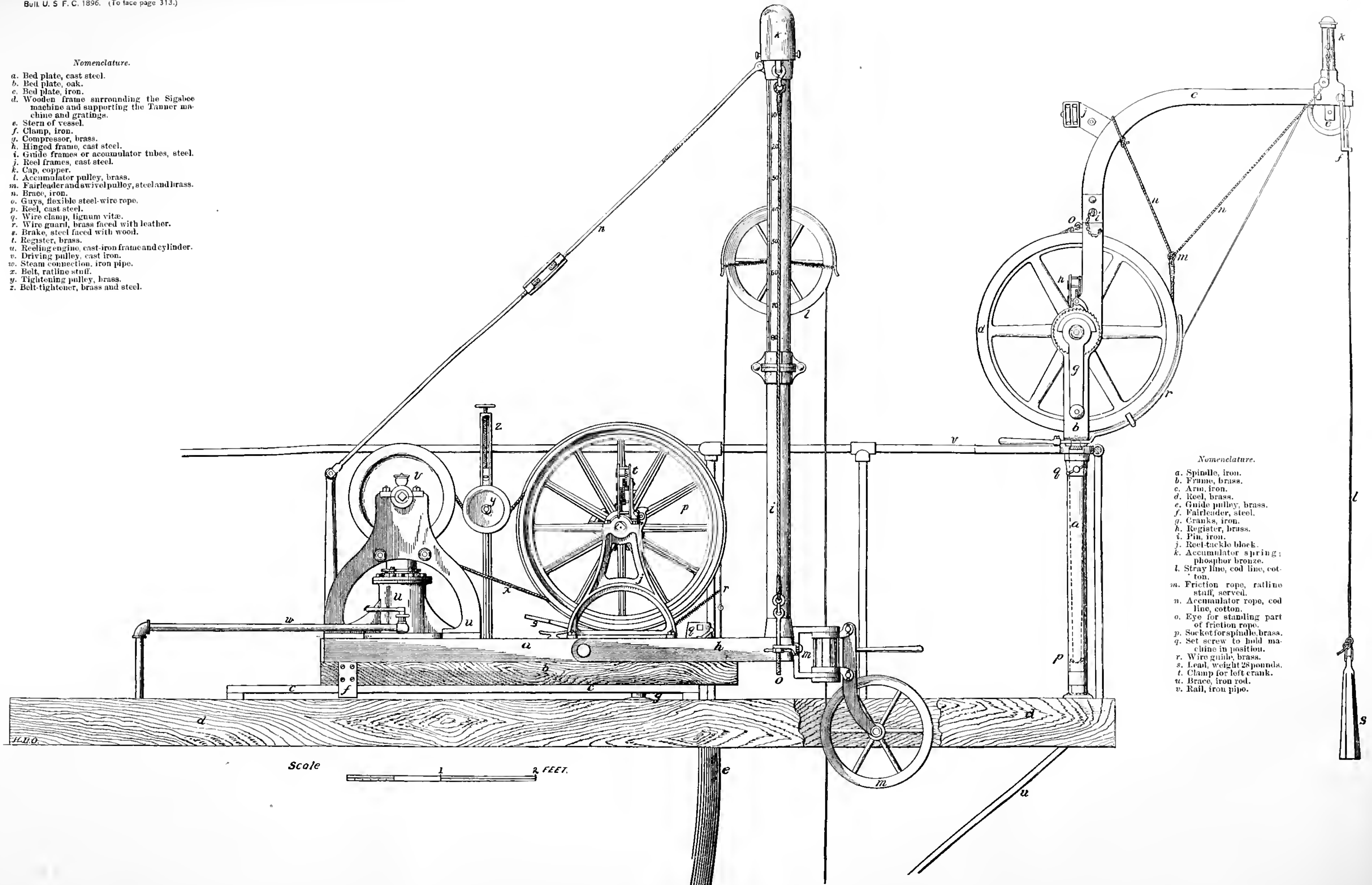
This admirable machine was constructed by Mr. D. Ballauf, Washington, D. C., under the personal supervision of the inventor, Commander C. D. Sigsbee, U. S. N., and is still in good condition after constant service of fourteen years. A few improvements have been added from time to time, yet it remains essentially the same as when received from the hands of the maker.

The aim of the inventor was to design a machine that should be light, strong, simple in structure, easily manipulated, and accessible in all its parts, yet compact and susceptible of snug stowage when not in use; hence steel was used whenever practicable, and brass was utilized for the minor parts where immunity from oxidation was of more importance than great strength.

It is secured to an iron bedplate by the clamps *f* and compressor *g* (plate XIX), and projects over the stern *e* sufficiently to allow the wire a clear passage from the machine to the water when rigged out for service, and is entirely within the line of the stern when rigged in. The wooden frame *d* surrounds the Sigsbee machine and supports the working platform and the Tanner machine. The platform consists of

Nomenclature.

a. Bed plate, cast steel.
b. Bed plate, oak.
c. Bed plate, iron.
d. Wooden frame surrounding the Sigsbee machine and supporting the Tanner machine and gratings.
e. Stern of vessel.
f. Clamp, iron.
g. Compressor, brass.
h. Hinged frame, cast steel.
i. Guide frames or accumulator tubes, steel.
j. Reel frames, cast steel.
k. Cap, copper.
l. Accumulator pulley, brass.
m. Fairleader and swivel pulley, steel and brass.
n. Brace, iron.
o. Guys, flexible steel-wire rope.
p. Reel, cast steel.
q. Wire clamp, lignum vitæ.
r. Wire guard, brass faced with leather.
s. Brake, steel faced with wood.
t. Register, brass.
u. Reeling engine, cast-iron frame and cylinder.
v. Driving pulley, cast iron.
w. Steam connection, iron pipe.
x. Belt, ratline stuff.
y. Tightening pulley, brass.
z. Belt-tightener, brass and steel.



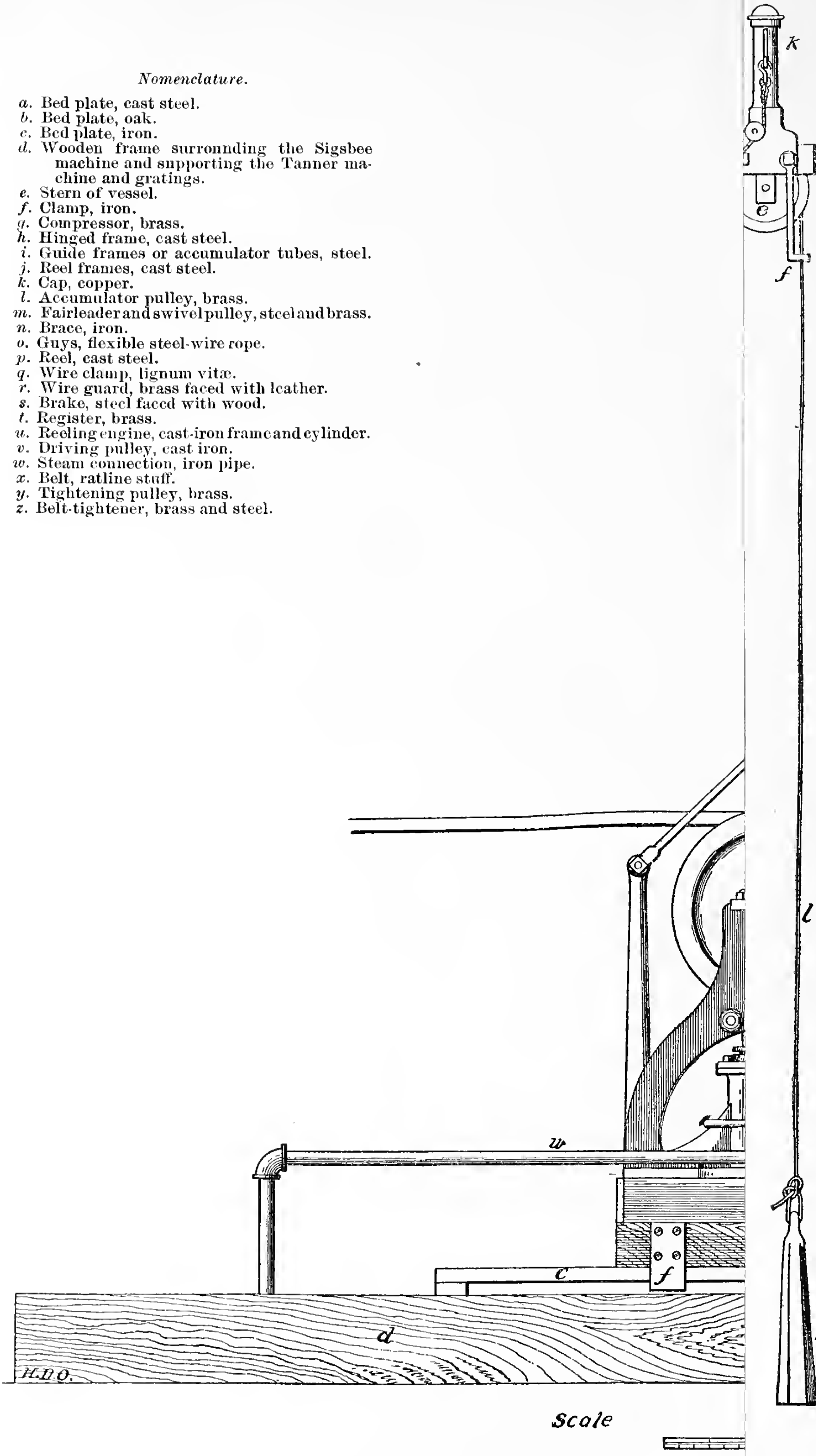
Nomenclature.

a. Spindle, iron.
b. Frame, brass.
c. Arm, iron.
d. Reel, brass.
e. Guide pulley, brass.
f. Fairleader, steel.
g. Cranks, iron.
h. Register, brass.
i. Pin, iron.
j. Reel-tackle block.
k. Accumulator spring; phosphor bronze.
l. Stray line, cod line, cotton.
m. Friction rope, ratline stuff, served.
n. Accumulator rope, cod line, cotton.
o. Eye for standing part of friction rope.
p. Socket for spindle, brass.
q. Set screw to hold machine in position.
r. Wire guide, brass.
s. Lead, weight 28 pounds.
t. Clamp for left crank.
u. Brace, iron rod.
v. Rail, iron pipe.

THE SIGSBEE AND TANNER SOUNDING MACHINES, AS INSTALLED AT THE STERN OF THE ALBATROSS.

Nomenclature.

a. Bed plate, cast steel.
b. Bed plate, oak.
c. Bed plate, iron.
d. Wooden frame surrounding the Sigsbee machine and supporting the Tanner machine and gratings.
e. Stern of vessel.
f. Clamp, iron.
g. Compressor, brass.
h. Hinged frame, cast steel.
i. Guide frames or accumulator tubes, steel.
j. Reel frames, cast steel.
k. Cap, copper.
l. Accumulator pulley, brass.
m. Fairleader and swivel pulley, steel and brass.
n. Brace, iron.
o. Guys, flexible steel-wire rope.
p. Reel, cast steel.
q. Wire clamp, lignum vitæ.
r. Wire guard, brass faced with leather.
s. Brake, steel faced with wood.
t. Register, brass.
u. Reeling engine, cast-iron frame and cylinder.
v. Driving pulley, cast iron.
w. Steam connection, iron pipe.
x. Belt, ratline stuff.
y. Tightening pulley, brass.
z. Belt-tightener, brass and steel.



gratings on either side and abaft the swivel pulley, the after one hinged to turn up when desired, as in taking serial temperatures.

The cast-steel bedplate a is securely bolted to the oak bedplate *b* for the double purpose of protecting the former from accidental strains and providing a convenient fastening for the machine.

The cast-steel frames j, which carry the reel *p*, are light and strong, and securely bolted to the frame *a*.

The guide frames or accumulator tubes *i* are steel pipes of commercial pattern. They are secured rigidly to the forward end of the hinged frame *h*, their upper ends terminating in a tie frame of cast steel, which carries two grooved pulleys on its upper surface designed to lead the accumulator rope from the springs to the pulley.

Hinged joints of cast steel are introduced near the middle length of the tubes *i* for convenience in attaching or adjusting the accumulator rope and compactness in stowing. They can be turned in either direction by removing a screw-bolt. An adjustable scale of brass, distinctly marked up to 80 pounds, is secured upon the upper after side of the right-hand tube *i*, where it is at all times under the direct observation of the man attending the friction rope and the engineer at the throttle of the reeling engine. The hinged frame *h*, of cast steel, is pivoted at its inboard end to the frame *a*, and extends outboard beyond the frames *a* and *b;* it is supported by the latter in prolongation of the frame *a*, and carries the guide frame *i*, the fair-leader, swivel pulley, and spur buffer. The frame moves freely from its horizontal position when rigged for service, to the vertical when folded for security, economy of space, or for transportation.

The accumulator rope may be of any material at hand, but ordinary coasting lead line has been successfully used on board the *Albatross*. To reeve a new rope, lower the upper section of the frame *i* to a horizontal position over the machine and remove the cap *k*, pull the end of the spring up to the joint with a chain hook or other convenient implement, bend one end of the rope to it, then run the other end up through the tube over its pulley, under the roller on the frame of the accumulator pulley, thence up over its pulley and down through its tube to the joint where it is bent to the spring which has been pulled up with a hook as before. The tension on the springs is determined by experiment in the following manner:

Elevate the frame *i* to a vertical position, reeve the stray line or other cord over the pulley and carry the standing part under the reel and make it fast, suspend a known weight to the hauling part, or, what is better, use an ordinary spring scale graduated to 150 or 200 pounds, which will be found very useful about the machine, putting on any desired strain until, by lengthening or shortening one end of the rope, the weight actually applied corresponds to that shown on the scale, the upper crosshead of the pulley frame being the indicator. Small adjustments may be readily made by easing the screws and moving the scale up or down on the tube.

It is advisable to verify the scale occasionally, especially after renewing the rope.

The accumulator springs are spiral, made of No. 4 steel wire (American gauge). They are 28½ inches in length, 2½ inches outside diameter, and have an elastic limit of about 4 feet, which gives the wire a cushioning of about 8 feet before it can be subjected to a violent jerking strain; and, what is even more important in modern practice, where the machine is located at the stern and the work of sounding carried on under all conditions of weather, the springs absorb an equal amount of slack wire

when, the stern being high in the air on the crest of a wave, it suddenly descends to the hollow of the sea with a velocity little inferior at times to the sinking of a sounding shot. This violent motion, under exceptional circumstances, is the only disadvantage of moment in placing the sounding machine at the stern, but with the Sigsbee machine it assumes little importance in comparison with the superior advantages of the location.

The accumulator springs, in connection with the scale, indicate the rapidly varying strains on the sounding wire during the descent of the sinker, and apprise the operator of the instant it strikes the bottom.

The cap k is a neatly fitted, water-tight, copper cover protecting the interior surfaces of the accumulator tubes, springs, rope, and pulleys from the weather. It is held in place by thumbscrews which are readily removed.

The accumulator pulley l is lightly constructed of brass, has a deep groove for the wire, and is mounted in such a manner that it can be readily removed from its bearings without displacing the frame. Guards of sheet brass are hinged to the frame above the pulley and carefully shaped to its surface, where they are held in place by delicate spiral springs to prevent the wire from jumping out of the groove in case it is suddenly slackened from any cause.

The cast-steel frame within which the pulley *l* is suspended is lightly constructed also in order to reduce its inertia to the lowest limit. The cross heads traverse freely on steel guides which are secured to the inner surfaces of the tubes *i*, along their whole length, giving to the pulley a vertical motion equal to the elastic limit of the accumulator springs, which is about 4 feet. Shoulders project from the pulley frame which impinge upon the spur buffer below, or springs above, to guard it from violent shock in case either the sounding wire or accumulator rope should break under heavy strain.

The spur buffer stands in a vertical position on the forward end of the frame *h* directly under the projecting shoulder of the frame which carries the pulley *l*. It consists of a steel tube containing a spiral compression spring, upon which a steel piston rests, its upper end projecting 2 inches above the tube, thus providing a safe cushioning for the accumulator pulley and frame in case the springs or accumulator rope should give way under tension.

The spring buffers are V-shaped steel springs on the middle lower surface of the tie-frame, each side of the accumulator rope. They are intended as a cushioning for the frame and pulley *l* in the event of the sounding wire parting under a heavy strain. The fair-leader and swivel pulley *m* guide the sounding wire to the accumulator pulley, the former when the wire is nearly vertical, and the latter when the angle is great, as would be the case when the vessel was drifting, turning, or steaming ahead.

The fair-leader is a cylinder of tempered steel, with rounded ends, bolted to the outboard end of the frame *i*, with its center directly beneath the outer score of the accumulator pulley. The swivel pulley has a deep groove for the wire, is of brass and very light; its steel frame is bolted to a collar that turns freely on the outer surface of the fair-leader in such a manner that the bottom of the groove on the inner periphery of the pulley *m* retains its position at all times directly beneath the outer score of the pulley *l* and center of the fair-leader.

The swivel pulley is indispensable when reeling in the sounding wire with the

vessel under headway, as is customary in modern practice. It is swung to one side out of the way when not required for use, and when taking serial temperatures fair-leader and pulley are removed from the machine. A steel rod, or handle, projects from the frame over the pulley *m* for convenience in swinging it back and forth to the desired angle.

The brace n is an iron rod connected to the head of the tubes *i* and to a strut of cast steel on the inboard end of the frame *a;* it is operated by a turn-buckle, through which its length is increased, thus forcing the head of the tubes forward and pressing the frame *h* down firmly on the oak bedplate *b*, where they are held in position when the machine is rigged for service.

The guys o are of flexible wire rope, with sister hooks in their upper ends which hook into eyes on the tie-frame, and screwbolts at the opposite ends, passing through holes at the outer extremities of a pair of outriggers of cast steel, which pivot on the end of the frame *h*. The guys being properly set up, support the accumulator laterally.

The reel p is of cast steel and known as the "navy reel." It is cast in one piece with 12 light-ribbed spokes; the drum is 22.89 inches in diameter, equal to a fathom in circumference, less 0.028 of an inch, the diameter of sounding wire, hence the initial turns are a fathom each; the face of the drum is 3½ inches wide and the reel will carry about 6,000 fathoms of wire. The weight of the navy reel is about 160 pounds. The V-shaped friction groove, common to all sounding reels, projects from the right flange and is cast with it; the drum, flanges, and friction groove, are lathe-finished.

The shaft, or axle, is of steel; the ends are squared for the reception of cranks and the reel is held in place by a key, which can be readily backed out; there is a ratchet wheel on the left of the reel, and a worm wheel on its right, into which the register *t* is geared. Both the ratchet and worm wheels are keyed on the shaft.

The navy reel is the only one that has been thoroughly reliable under all conditions of service on board United States vessels, and is to be preferred on that account, notwithstanding its great weight, which is really of little moment when used with the carefully adjusted accumulator of the Sigsbee machine. A little closer attention to the friction rope is all that is required on the part of the operator to overcome the effect of increased inertia.

Experiments were made on board the *Albatross* with ingeniously devised and carefully constructed built-up reels, under the impression that it was vitally necessary to keep the weight down; weaknesses were developed when working in great depths and the parts strengthened until the reel increased from 90 to 150 pounds in weight; it failed even then under a crushing strain of about 300 tons.

The friction rope is of 18-thread manila, 2 fathoms in length, with an eye spliced in the standing part. To reeve it for sounding, slip the eye over its cleat on the bedplate *a*, lead the hauling part under the reel, then over it and through the V friction groove; the operator stands forward of the machine, facing it, with the friction line in one hand, and with the other steadying himself in rough weather, which he can do without distracting his attention or interfering with the delicate manipulation of the friction rope, upon which successful sounding so largely depends. He can stop the reel promptly by a moderate pull on the line with one hand, and a further advantage gained by this direct method of running it is that the accumulator is left entirely free to indicate the rapidly varying tension on the sounding wire, which it does with marked

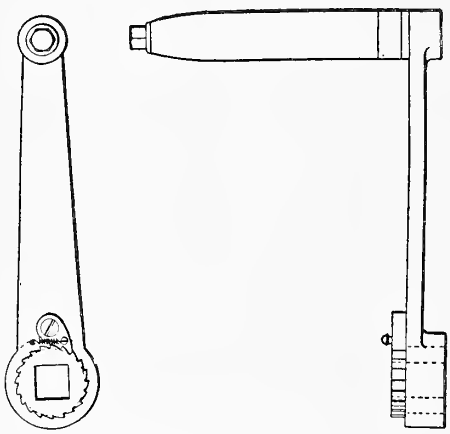
precision under all conditions of service; hence the actual resistance imposed upon the reel by the friction line becomes a matter of indifference.

The wire guard r is a T-shaped brass plate hinged to the bedplate *a*. Its head is faced with sole leather and covers the width of the reel between the flanges. The leather rests fairly on the wire when it is in action and a gentle pressure is maintained by a spiral spring attached to the middle of the upright part of the T and to the bed-plate *a* under light tension. The contact of guard and wire takes place at the forward lower quarter of the reel and is intended to supplement the action of the friction line by supporting the slack turns of wire and causing them to be seen more quickly on the upper surface, also to prevent their flying off from the lower part of the reel before they are apparent to the eye of the attendant.

While the relief afforded by the guard is momentary only, it serves to give timely warning to the vigilant operator who is speeding his work by veering wire to the utmost limit of safety.

The brake s is practically indispensable when, from the breaking of a belt or friction line, the reel becomes unmanageable and can not be safely stopped by throwing the pawl into action.

The register t is of brass and has three dials marked for units, hundreds, and thousands; its gearing engages the worm wheel on the axle of the reel, and can be quickly thrown into or out of action, or removed from the machine. It registers the number of turns of wire paid out, the corresponding number of fathoms being found by reference to a correction curve or table prepared for each reel.



CUT 38.—Ratchet crank, front and side views.

The reeling engine *u* is a Copeland & Bacon half trunk, designed for the purpose, 6½-inch cylinder and 6-inch stroke; it has a light-iron frame, cast in one piece, and is bolted securely upon the inboard end of the bedplate *a*. The driving pulley *v* has a V-groove corresponding to that on the reel *p*, over which the belt *x* is run; the steam connection *w* is on the right side of the cylinder, and the exhaust valve and steam chest are on its left side.

Flexible hose, or rigid steam and exhaust pipes, may be used, and where the machine rigs out and in it may be advisable to have a pipe connection on the deck near it and a flexible attachment admitting of the necessary movement.

The ratchet crank ships on the squared end of the crank shaft of the reeling engine and is used to work water out of the cylinder, also to assist in starting the engine slowly to avoid sudden and undue strain on the sounding wire; it can be unshipped after the engine has been started or left hanging in place, where it will remain in a vertical position, the ratchet preventing its revolving with the shaft. Cut 38 shows front view and side view of the ratchet crank. It was devised by the writer and constructed by Chief Engineer Baird of the *Albatross*.

The belt x is of 18 or 21 thread ratline stuff, made in the form of a grommet strap, with small sewed seizings covering the ends in the splice, to prevent their working

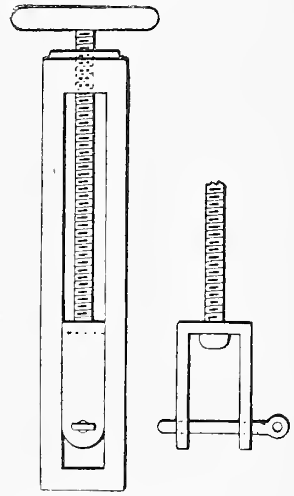
out as the belt becomes stretched. Experiments were made with leather, gutta-percha, manila, etc., for belts, but we found nothing to compare with ratline stuff, which is quickly fitted on board ship, performs its work well, and is fairly durable.

The tightening pulley y, deeply scored to receive the belt, revolves on a stud or axle projecting from the side of a movable collar that traverses freely on a vertical standard erected from the bedplate *a* between the engine and reel.

The belt-tightener z consists of a small steel rod having a screw thread on its whole length, a swivel joint and pin on its lower end, and a small hand wheel on its upper extremity. Its frame is of brass, cylindrical in form, and has a slot running nearly its whole length, in which the rod and swivel joint work. A round hole in the lower end of the frame allows it to slip over the end of the tightening-pulley standard, and there is a screw thread in the other end which engages the thread on the rod.

To operate the belt-tightener, put the belt on the reel and driving pulley, place the tightening pulley on the upper part of the belt, slip the belt-tightener over the end of the standard, and pass the pin through a hole in the swivel joint; then, by revolving the hand-wheel, screw the base of the frame down upon the collar until the desired tension is obtained, which is easily and quickly done with one hand. Should the belt stretch so much that it can not be set taut with the belt-tightener it is only necessary to slip a few washers, or a piece of pipe 3 or 4 inches long, on the standard between the belt-tightener and movable collar.

It was formerly the practice on the *Albatross* to put a tension on the belt by pressing the pulley down by hand and retaining a uniform strain by the elastic pressure of a spiral spring. It required the united efforts of two or three men to get the belt sufficiently tight. Even then it would slip at times when working in deep water; hence the necessity for a mechanical belt-tightener, which has proved to be simple and effective. Cut 39 shows a general view of the belt-tightener and a side view of the swivel joint and pin.



Cut 39.—Belt-tightener.

The Sigsbee wire clamp (cut 40) is composed of two pieces of lignum-vitae, semi-circular in form, with right and left hand screws for operating it. It is used for holding the sounding wire in case it becomes necessary to slacken it between the reel and swivel pulley; for instance, if it flies off the reel, or a defective splice, kink, or slack turns are discovered.

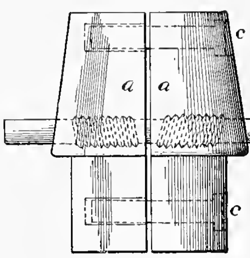
To use the clamp, slip the wire between the flat surfaces of the jaws, as shown at *d*, set them firmly against it by means of the right and left hand screws, and lower it into the fair-leader. To suspend the submerged wire and sinker by the accumulator, put the clamp on between the pulley and reel, lashing it well down, below the elastic limit of the springs; but this will seldom be necessary or desirable in practice. The clamp is carried in a socket inside of the bedplate *a*, on the left side, between reel and accumulator frame, where it is available for immediate use. It is held in its socket by expanding the jaws through the reverse action of the right and left hand screws.

The wire guide is used to lead the sounding wire fairly upon the reel. It is a round piece of wood, 9 inches in length and 1½ inches in diameter, covered with heavy pump

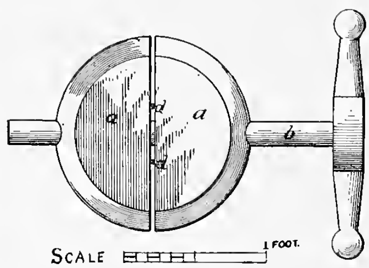
leather for half of its length, the leather being nailed on with headless copper tacks, to avoid the possibility of catching the wire. There is a becket through a hole near the end of the handle.

To protect the leather from unnecessary wear, it should be kept well oiled. It will usually receive an ample supply from contact with the wire.

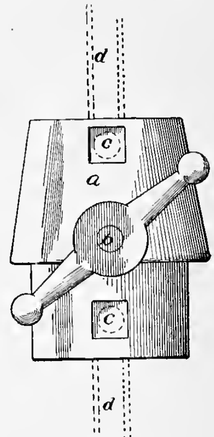
To use the wire guide, take it in the right hand, slip the becket over the wrist, grasp the brace of the sounding machine with the left hand for support, if there is much motion on the vessel, then press the leather-covered surface lightly against the wire with sufficient force to guide it evenly upon the reel. It should be made an invariable rule to use the guide, even though a few fathoms only have been run off, in



CUT 40.



CUT 41.



CUT 42.

a. Lignum-vitae jaws.
b. Spindle, with right and left hand screws.
c. Guide bolts, brass.
d. Sounding wire.

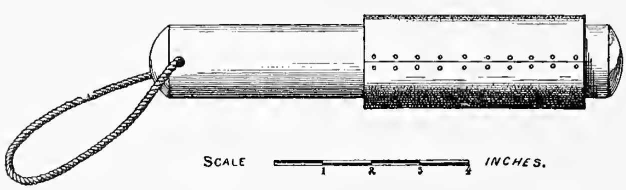
CUT 40.—Side view of the Sigsbee wire clamp, showing jaws *a* and right and left hand screws by which they are opened and closed; also guide bolts *c*, which are rigidly set into right jaw and slide freely in the left.

CUT 41.—Top view, showing ends of jaws *a*, between which are gripped two pieces of sounding wire *d*.

CUT 42.—Front view, showing manner of clamping the wire.

order to guard against the exasperating occurrence of slack turns of wire on the reel. The guide is very useful, also, in the hands of an expert, for detecting kinks or defective splices, which are rarely discernible by sight on rapidly running wire.

The *dynamometer staff and spring* were devised by the writer in 1891 for the purpose of facilitating the guiding of the sounding wire upon the reel with the least possible friction on the splices, reducing the manual exertion required to guide it, and avoiding the danger and annoyance resulting from slack turns.



CUT 43.—The wire guide.

In sounding with the Sigsbee machine, the accumulator pulley, over which the wire leads, has a vertical motion nearly the entire length of the tubes within which its controlling springs are inclosed, and a scale on the right tube indicates the tension on the wire, as well as the moment the sinker strikes bottom. Nothing better can be desired during the paying out, but the greater strain brought upon the wire while reeling

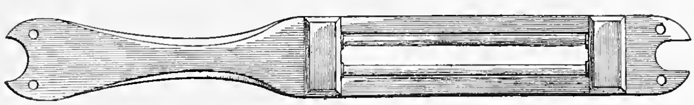
in tends to draw the pulley down so near the reel that it is difficult and at times impossible to guide it evenly upon the drum; hence the necessity for a simple method of suspending the pulley at the top of the frame, at the same time retaining the dynamometer, or adopting another by which the strain on the wire may be noted.

The dynamometer staff is a brass tube of commercial pattern, cut to the desired length, and an eye of cast brass secured in its upper end. At the lower extremity is a spiral compression spring of phosphor bronze, $1\frac{3}{4}$ inches in diameter and 8 inches long, held in place by a small shoulder and drift pin.

To use it, the sinker having been detached, place the spiral spring over the top of the spur buffer, lift the pulley to the top of the frame, and secure the eye of the staff in the socket at the lower extremity of the crosshead frame by a loose pin provided for the purpose. With the pulley in this position, the wire is guided upon the reel with the minimum of exertion and friction, and the elastic limit of the spring, about 4 inches, being divided off as a scale on the left accumulator tube, the strain put upon the wire is under the constant observation of the operator.

The scale is marked from 100 to 130 pounds, the tension being obtained by clapping a spring scale on the end of the stray line, and with a piece of chalk marking the lines as desired; it is the work of a moment and preferred to a permanent scale, which would require frequent verification. Either arm of the crosshead may be used as a pointer, but the lower one, being nearly on a level with the eye, is preferable.

The adoption of the staff interfered with the use of the main accumulator while reeling in, but the machine being located at the stern and the vessel steaming ahead there was no fear of fouling, and the danger from jerking strains in a seaway being much reduced by the trend of the wire astern no inconvenience was suffered from the new arrangement. The speed of the reel was governed entirely by the strain upon the wire; 110 pounds was considered thoroughly safe practice, 120 pounds was the ordinary working strain, and 130 pounds the extreme limit of safety, which was not exceeded under any circumstances. With the introduction of the dynamometer staff the speed of the reeling engine was increased, the danger from slack turns on the drum disappeared, and a noticeable decrease was observed in losses from defective splices.



Cut 44.—Guide for temperature wire.

The guide for the temperature wire, as improvised by the writer in 1891 and first used aboard the *Albatross* on the cable survey between California and the Sandwich Islands, has an oak frame in which is a long slot carrying a pair of brass rollers, lashings being provided at each end for convenience in securing it in place. To prepare it for use, remove the fair-leader and swivel pulley from the sounding machine, ship the dynamometer staff, lash one end of the guide to it just below the accumulator pulley, securing the other wherever most convenient; then, having mounted the reel containing the temperature wire, run the stray line over the pulley and between the rollers on the guide and bend on the sinker.

With this arrangement of guide, thermometers and water bottles are fastened to the wire and removed from it at a convenient height above the grating, which is a convenience at all times, and particularly so in heavy weather.

THE TANNER SOUNDING MACHINE.

This machine was devised by the writer in 1880, for use on board the United States Fish Commission steamer *Fish Hawk*, which was provided with deep-sea apparatus designed to operate in depths within 500 fathoms. It is a hand machine for sounding with wire, and can be operated by one man, but two will work more rapidly, and, if sounding in 200 fathoms or more, time will be saved by having a relief at the cranks. Soundings in 800 fathoms have been made with the machine, and the reel has even a greater capacity, but it is lightly constructed and not intended to bear the crushing strain imposed upon it by working in greater depths.

It is mounted at the stern of the *Albatross* abaft the Sigsbee machine, carries about 500 fathoms of No. 21 music (Washburn & Moen) wire, with which an ordinary 28-pound lead is used; it is kept in readiness for navigational purposes whenever the vessel is underway, and soundings within its capacity are quickly and accurately made by stopping and getting an up-and-down cast, while from 70 to 100 fathoms may be readily reached without checking the speed by attaching a Bassnett atmospheric sounder or Sir William Thomson's tube to the stray line.

The Tanner machine is used also in deep-sea exploration in depths within 200 or 300 fathoms, and while the Sigsbee machine is preferred in deeper water the former is occasionally used even in 500 fathoms.

It is necessary to keep the wire taut when sounding with this machine as well as with others, for slack wire is liable to fly off the reel or kink, and the latter is usually followed by a break.

The spindle a is made of iron, turned slightly tapering, screwed firmly into the base of the frame *b*, and inclosed within a brass tube. There is a brass bearing on the rail through which the spindle passes, the lower end resting in the socket *p*. The set screw *q* holds the machine in any desired position.

The frame above mentioned is of brass, cast in one piece, is bored to receive the reel shaft, and has appropriate lugs for the pawl and register. The reel *d* is of cast brass, 22.89 inches in diameter; the initial turns of wire equal 1 fathom, increasing as the score is filled, its capacity being about 2,000 fathoms of No. 11 music.

The V *friction groove*, common to all sounding reels, is on the right flange, and is part of the same casting.

The cranks g, by which the reel is turned, have conical friction surfaces, which are brought into contact with similar surfaces on the ends of the reel shaft by moving the right crank one-half a revolution ahead, the left one remaining clamped at *t*, or held firmly in the hand. The reverse motion releases the reel, allowing it to revolve freely without moving the cranks. On the left side, between the frame and crank, is a worm wheel which operates the register *h*. The ratchet and pawl are shown on the right, between the frame and crank.

The arm c, which supports the guide pulley *e*, is of iron, hinged between lugs on the frame, and held in position by the pin *i*. The small metal reel-tackle block *j*, projecting from the arm, is part of a tackle for suspending the reel when mounting or dismounting.

The guide pulley e is of brass, with a V groove, the upper portion being covered with a guard to prevent the wire from flying off. The pulley is hung on a frame, having a spindle extending into the metal casing above, the small arm *k* being confined

to its upper end by a nut. A spiral accumulator spring surrounds the spindle, and is compressed by the weight of the lead *s*, giving the guide pulley *e* a vertical play of about 3 inches. The fair-leader *f* swings freely in and out, but is rigid laterally, and guides the wire fairly into the score of the pulley. The aperture through which the wire passes is lined with highly tempered steel.

The standing part of the friction rope *m* is spliced into the eye *o* in the frame, carried around the reel in the V groove, and the free end secured to the bight of the accumulator rope *n* at *m*, one end of the latter being hooked to the small arm *k*, and the other made fast to the arm *c*, for the purpose of supporting the friction rope when it is slack and preventing its flying out of the V groove. The guide *r* leads the wire fairly on the reel. The machine revolves freely, its weight being sustained by the socket *p*. The set screw *q* holds it in position.

To take a sounding, the wire being on the reel and the latter mounted, haul the friction rope hand-taut before the lead is attached and while the guide pulley is up in place. In this position it requires a strong man to move the reel, but the lead being bent and suspended, it compresses the accumulator spring and drags the pulley down sufficiently to slack the friction rope and allow the reel to revolve with comparative freedom. The instant the lead strikes the bottom, however, or the weight is removed from any cause, the pulley flies up, putting a tension on the friction rope, which checks the reel.

The friction rope being properly adjusted, reeve the stray line over the guide pulley and bend on the lead. Throw the pawl out of action, attend the friction rope, and lower the lead to the water; set the register at zero, and take the cast, governing the speed of descent by means of the friction rope, which is grasped by the right hand at *m*. As soon as the lead reaches bottom, bring the cranks into action by turning the right one a half turn ahead, read the register, unclamp the left crank at *t*, throw the pawl into action, and heave in. When the lead is up, clamp the left crank at *t*, move the right one a half turn back, thus throwing them out of action, and the machine is ready for another cast.

If there is much sea running it is necessary to use a light lead attached to the upper end of the stray line to prevent kinking the wire when slackened by the vessel's pitching.

To dismount the reel, reeve the tackle *j* and take the weight off the shaft; remove the nut from the left end of the shaft, grasp the ratchet wheel with both hands, and withdraw the shaft and right crank, leaving the left crank and worm wheel in position, swing the reel clear of the frame and lower it to the deck, returning the shaft and crank to their places. If the frame is to remain on the rail, remove the register and lower the arm *c* by withdrawing the pin *i*, ease up the set screw *q*, swing the arm inboard, then tighten it to hold the machine in position.

To wholly dismount the machine for transportation or storage, remove the reel, cranks, and register, disconnect the arm *c* at *i*, and unscrew the spindle *a* from the base of the frame *b*. The total weight of the machine is 135 pounds.

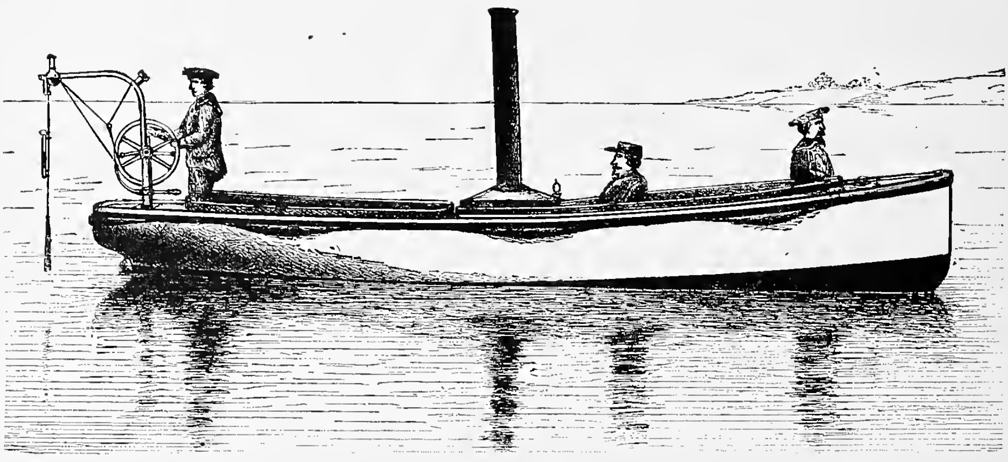
If the ordinary sounding wire (No. 11 music) is used, it is necessary to protect it from oxidation by keeping it oiled when mounted, and in a reel tank when not in use. But with a view of having it ready for service at all times without the necessity of giving special care to the wire No. 21 music is used and allowed to remain on the reel without other protection than occasional oiling. It rusts, as a matter of course,

but it is serviceable for a year, at least, and sometimes lasts two years. This heavy wire is recommended for use in depths not exceeding 500 fathoms.

The Tanner machines recently made have been simplified in construction by dispensing with the inner and outer shafts and conical friction surfaces for engaging the cranks and substituting therefor a single cylindrical shaft with its ends squared for the reception of sleeves which form cylindrical bearings for the cranks, both being held in place by washers and set screws in the ends of the shaft. The cranks are thrown into and out of action by spring-controlled locking-bolts, carried on their rear surfaces, which pass through holes in hubs of cranks and into the sleeves. The worm wheel and ratchet are carried on the cylindrical body of the shaft, between the sleeves and the frame, and are held with set screws. The reel is also secured in the same manner.

THE TANNER SOUNDING MACHINE FOR BOAT SERVICE.

It is frequently desirable to extend lines of soundings from one or two to several hundred fathoms, with the same vessel and apparatus, and the Tanner machine being well adapted for boat work, was installed at the stern of the *Albatross'* steam cutter, with fittings similar to those on board ship, and has performed excellent service.



Cut 45.—The Tanner sounding machine mounted in the steam cutter.

When a sounding is about to be taken the cutter is stopped as quickly as practicable, maneuvering to keep the wire vertical during its descent, and as soon as the lead strikes bottom she steams ahead again at full speed, the wire being reeled in while she is under headway. Short base lines are quickly measured by making the stray line fast, setting the register at zero, and steaming directly for the opposite end, attaching as many floats en route as are necessary to support the wire at the surface. The reading of the register is corrected as in sounding. The same method will apply on a smooth stretch of land by mooring the boat and walking away with the wire.

This is not a rigidly accurate method, but, for short lines, the results will be found to compare favorably with those obtained with the surveyor's chain.

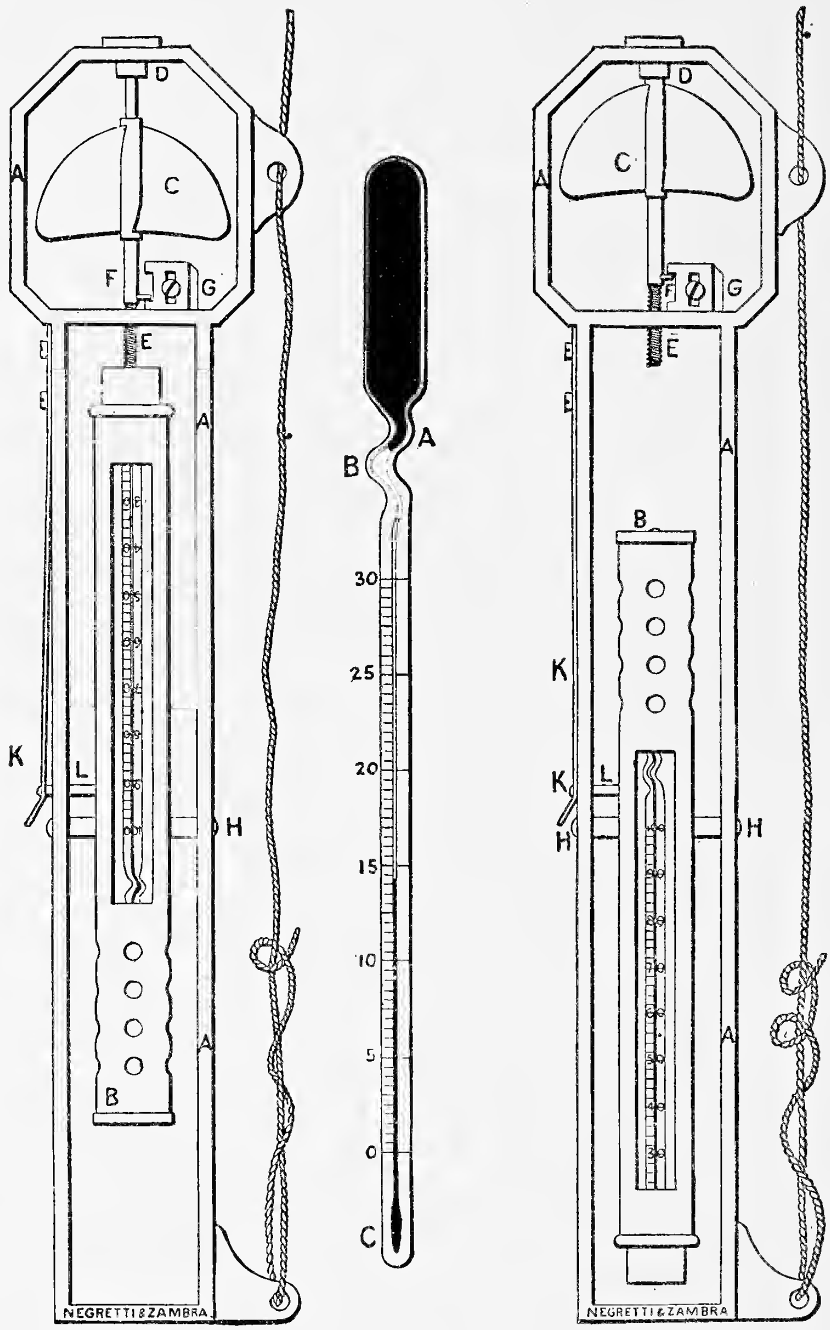


Fig. 1. Fig. 2. Fig. 3.

THE NEGRETTI & ZAMBRA DEEP-SEA THERMOMETER AND MAGNAGHI FRAME.

THERMOMETERS.

Thermometers were procured from various manufacturers during the earlier operations of the Fish Commission and issued for service without previous comparison with a standard. Only the best instruments of reputable makers were used, and observations were confined to air temperatures, surface, shoal water, and moderate depths, hence they did not suffer materially until the scope of temperature observations enlarged in the direction of the deep sea, when instrumental errors became of sufficient frequency to cast discredit upon them.

Systematic and successful efforts were made by the officers of the Commission to improve this branch of the service; greater care was exercised in the selection of instruments; makers were informed of weak points developed in service and encouraged to remedy them; all thermometers were rigidly compared by an officer of the Commission and were accompanied by tables of corrections when issued for service. The accompanying description will include only the thermometers of the *Albatross*, as they represent the types in use on board the vessels of the Commission.

Thermometers for air temperatures are made by J. & H. J. Green, New York. The tubes are 10 inches in length, made extra strong, well seasoned, and graduated on the stems to 1° F. They rate with remarkable uniformity, with a maximum error of 0.3°, minimum of 0.0°, and mean of 0.1°. They are mounted in extra heavy copper cases, open in front, with a cup in the bottom perforated with a central hole.

Wet-bulb thermometers are the same as those above described and are prepared for their special function by having their bulbs enveloped in lamp wick, which being immersed in a suitable cup of fresh water placed beneath the suspended instrument saturates the fibers surrounding the bulb by capillary attraction.

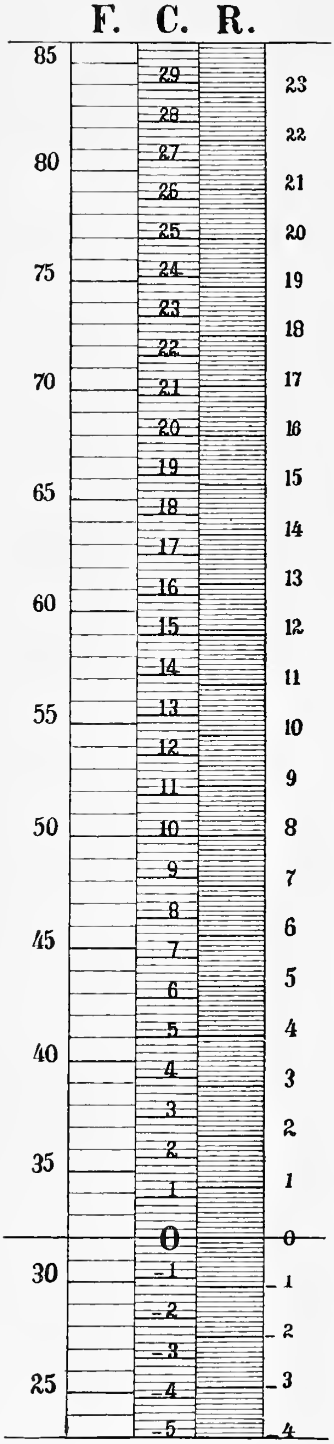
Thermometers for surface temperatures are the same as before described for air, and are prepared for use by inserting a cork into the central hole in the bottom of the frame.

The *Tagliabue thermometers* attached to the Hilgard ocean salinometers are simple tubes, with round bulbs, protected by perforated brass cages and fitted to slide into the front of the salinometer cup. The older make, graduated on the stems to 1° F., range from 30° to 100°, while later forms are graduated to 1° centigrade, and range from —10° to + 50°.

THE NEGRETTI & ZAMBRA DEEP-SEA THERMOMETER.

The following description is copied in part from the catalogue of Negretti & Zambra. The construction of the thermometer will be understood by reference to fig. 2, plate XX, and its shield is shown in fig. 2, plate XXI, in a vertical sectional elevation of the Tanner deep-sea thermometer case.

The thermometrical fluid is mercury; the bulb containing it is cylindrical, contracted in a peculiar manner at the neck *a*; and upon the shape and fairness of this contraction the success of the instrument mainly depends. Beyond *a* the tube is bent and a small catch reservoir at *b* is formed for a purpose to be presently explained. At the end of the tube a small receptacle *c* is provided. When the bulb is downward the glass contains sufficient mercury to fill the bulb, tube, and a part of the receptacle *c*, leaving, if the temperature is high, sufficient space in *c*. When the thermometer is held bulb upward, the mercury breaks at *a*, and by its own weight flows down the tube filling *c* and a portion of the tube above *c*, depending upon the existing temperature. The scale is accordingly made to be read upward from *c*.



Cut 46.—Comparative thermometric scale Fahrenheit, Celsius, and Reaumur.

To set the instrument for observation it is only necessary to place it bulb downward, when the mercury takes the temperature, just as in an ordinary thermometer. If at any time or place the temperature is required, all that has to be done is to turn the thermometer bulb upward and keep it in this position until the reading is taken. This may be done at any time afterward, for the quantity of mercury in the lower part of the tube which gives the reading is too small to be sensibly affected by a change of temperature unless it is very great, while that in the bulb will continue to contract with greater cold and to expand with great heat. In the latter case some mercury will pass the contraction *a* and may fall down and lodge at *b*, but it can not go further so long as the bulb is upward, and thus the temperature to be read will not be affected.

Now, whenever the thermometer can be handled it can readily be turned bulb upward for reading the existing temperature. It must be clearly understood that this thermometer is only intended to give the temperature at the time and place where it is turned over; it is simply a recording thermometer. In its present state it can not be used as a self-registering maximum and minimum, though, if required, it could be constructed to act as a maximum.

In order to make the thermometer perfectly satisfactory, it was necessary to protect it from pressure as well in shallow as in the deepest seas, for in either case the pressure would cause an error of greater or less degree in its indications. Like an ordinary thermometer it is devoid of air, and so quite different from Sixe's, which, containing compressed air, has a certain internal resistance. Hence it would be more affected by pressure than Sixe's thermometer, however thick the glass of the bulb. By the simple expedient of inclosing the thermometer in a glass shield, *c* [plate XXI, fig. 2], hermetically sealed, the effect of external pressure is entirely eliminated. The shield must of course be strong, but not exhausted of air. It will, however, render the inclosed thermometer less readily affected by changes of temperature, making it more sluggish.

To counteract this tendency mercury is introduced into that portion of the shield surrounding the bulb, and confined there by a partition, *d*, cemented in the shield around the neck of the thermometer bulb. This mercury acts as a carrier of heat between the exterior of the shield and the interior of the thermometer; and the efficacy of this arrangement having been experimentally determined, the instrument has been found far superior in sensibility to Sixe's.

So long as the shield withstands the pressure—that is, does not break—the thermometer will be unaffected by pressure, and there is abundant experience to show that such a shield will stand the pressure of the deepest ocean. Doubtless the shield will be slightly compressed under great pressure, but this can never cause an internal pressure sufficient to have an appreciable effect upon the thermometer. This method of shielding is, therefore, quite efficacious, and deep-sea thermometers so protected do not require to be tested for pressure in the hydraulic press. They simply require accurate tests for sensitiveness and for errors of graduation, because they are standard instruments adapted to the determination of very small as well as great differences in temperature, some one or two tenths of a degree in shallow water. The test for sensitiveness should determine the time the instrument requires to take up a change of 5°, rise or fall, and the time is found to be from five to ten seconds.

Thus, provided the turning-over gear is found to answer, this instrument evidently possesses great advantages. It has no attached scale, the figures and graduations being distinctly marked on the stem itself, and the shield effectually preserves them from

obliteration. The part of the stem which forms the background to the gradnations is enameled white to give distinctness to the mercury.

To make this instrument available for deep-sea use it is necessary to provide some reliable method of turning the bulb upward at the proper time; also, to prevent it from turning down again before the surface is reached and the temperature read.

Plate XX shows a metal frame devised by Commander Magnaghi of the Italian navy. It is described as follows in an advertisement of Messrs. Negretti & Zambra:

Negretti & Zambra's patent improved frame standard deep-sea thermometers.—A is a metallic frame in which the case B, containing the thermometer, is pivoted upon an axis H, but not balanced upon it. C is a screw fan attached to a spindle, one end of which works in a socket D, and on the other end is formed the thread of a screw E, about half an inch long, and just above it is a small pin or stop F, on the spindle. G is a sliding top-piece, against which the pin F impinges when the thermometer is adjusted for use. The screw E works into the end of the case B, the length of play to which it is adjusted. The number of turns of the screw into the case is regulated by means of the pin and stop-piece. The thermometer in its case is held in position by the screw E and descends into the sea in this position (fig. 1), the fan C not acting during the descent because it is checked by the stop F. When the ascent commences the fan revolves, raises the screw E, and releases the thermometer, which then turns over and registers the temperature of that spot, owing to the axis H being below the center of gravity of the case B as adjusted for the descent. Each revolution of the fan represents about 2 feet of movement through the water, so that the whole play of the screw requires 70 or 80 feet ascent; therefore, the space through which the thermometer should pass before turning over must be regulated at starting. If the instrument ascends a few feet by reason of a stoppage of the line while attaching other thermometers, or through the heave of the sea, or any cause whatever, the subsequent descent will cause the fan to carry back the stop to its initial position, and such stoppages may occur any number of times provided the line is not made to ascend through the space necessary to cause the fan to release the thermometer.

When the hauling in has caused the turn-over of the thermometer the lateral spring K forces the spring L into a slot in the case B and clamps it (fig. 3) until it is received on board, so that no change of position can occur in the rest of the ascent from any cause.

The case B is cut open to expose the scale of the thermometer, and is also perforated to allow free entry of the water."

The Magnaghi frame above described is a great improvement on the wooden cases formerly furnished by the makers, but even this did not prove entirely satisfactory in all respects, inasmuch as it could not be secured to sounding wire, and could not, therefore, be used in series. The fan failed to act occasionally, and the springs K and L were apt to hold the case B in a vertical position by friction, thus preventing the turn over at the proper time.

This thermometer was first used by the Fish Commission in 1877, when it was mounted in a wooden case about 13 inches in length, secured to the lead line by a lanyard at the bulb end. A cylindrical cavity contained a quantity of shot, movable from end to end, sufficient to nearly overcome its buoyancy in sea water. On sending the case down the friction of the water, aided by the buoyancy of the case, tended to keep it upright and bulb down in the water, the shot rolling promptly to the lower end of the cavity. Reversing the motion and hauling in the line the case was capsized and the shot run to the other end, tending to keep it down and the bulb uppermost.

This arrangement answered its purpose at moderate depths in smooth water where veering and hauling of the lead line could be made continuous, but the motion of the vessel in a moderate seaway was sufficient to capsize it again and again, and the case lost its buoyancy in about 600 fathoms, the wood becoming waterlogged. Many attempts were made, both in this country and in Europe, to improve the case, and in September, 1880, the writer attached a spring latch to the end opposite the

bulb, which, grasping the wire, held the thermometer in a vertical position during its descent and, when ready to haul up, the latch was disengaged by the impact of a metallic messenger sent down on the wire, and the thermometer promptly capsized by the preponderance of weight, the shot having been blocked in the free end of the case.

The next improvement, introduced a few days later, was simply a brass tube, seven-eighths inch in diameter, in which the thermometer was placed and held in position by rubber rings. The bulb end was secured to the sounding line by a lanyard and the other end carried a pair of slip hooks, which, encircling the line, insured a vertical position, bulb down, during its descent. It was reversed by impact of a messenger, as before, and, having no buoyancy, it retained its position, bulb up, even if the reeling in was interrupted or the vessel was laboring in a seaway. The messenger was of brass, cylindrical in form, with rounded ends, and weighed from 3 to 4 ounces.

This device became known as the Tanner case and proved efficient in the moderate depths sought by the *Fish Hawk*, but, in anticipation of more extended explorations on board the *Albatross*, then under construction, I considered it necessary to devise some method of registering in deep water without the loss of time incident to the descent of a messenger. The propeller of the Sigsbee water bottle suggested a simple and reliable method of reversing at any desired depth and permitting the use of any number of instruments in series.

The attention of Passed Assistant Engineer William L. Baillie, U. S. N., being called to the matter, he devised the propeller attachment which screwed to the upper end of the Tanner case, the slip hooks being removed for the purpose. The action of the propeller is practically the same as in the Magnaghi frame, received later in the same year. The device became known as the Baillie-Tanner case. It operated perfectly, so far as the prompt and unfailing overturning of the thermometer was concerned, but the weight, bulk, and general form of the free end was such that it subjected the delicate instrument to undue jarring on the way up, frequently shaking the mercury down from the bulb or catch reservoir into the tube and vitiating the observation. It was used in common with the Magnaghi frame, each having its merits, but both were lacking in some essential qualities and were superseded late in the season of 1883 by the device described below.

THE TANNER IMPROVED THERMOMETER CASE AND SIGSBEE CLAMP, USED WITH THE NEGRETTI & ZAMBRA DEEP-SEA THERMOMETER.

Fig. 1, plate XXI, shows the apparatus complete, and fig. 2 a vertical sectional elevation of the metal case containing the thermometer. The frame is of brass, cast in one piece, as light as is consistent with the required strength.

The case *f* is a brass tube of commercial pattern, 1 inch in diameter. It has a piece of metal soldered in its lower end to support the spiral spring *h*, and pivots to the frame at *j*. The cap *i* is screwed upon the upper end of the case, and is pierced with a central hole for the reception of the spindle *o*, carrying the propeller *n*, which is secured to it by a through drift pin. The upper part of the spindle has a screw thread, which works in a thread in the head of the frame. Its lower part has a plain surface, with rounded end, and revolves freely in its bearing and in the hole in the cap *i*. The set screw *p* regulates the distance the thermometer must be drawn up through the water before it is overturned and the temperature registered. The range is from 3 to 25 fathoms. The clamp *q* is the Sigsbee clamp used by him on water bottles and the Miller-Casella deep-sea thermometer. It is of phosphor bronze and performs its work admirably either on the stray line or sounding wire. When clamping to the latter,

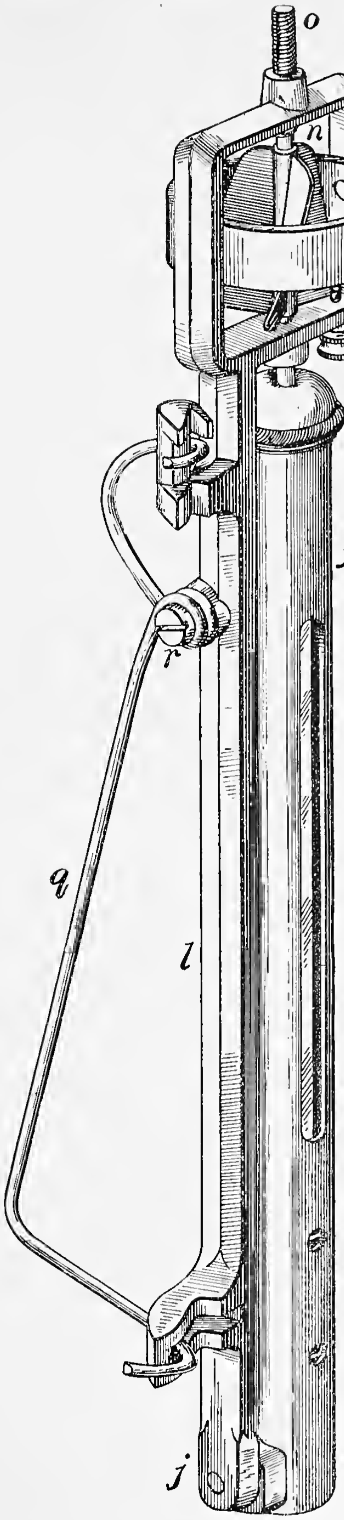


Fig. 1.

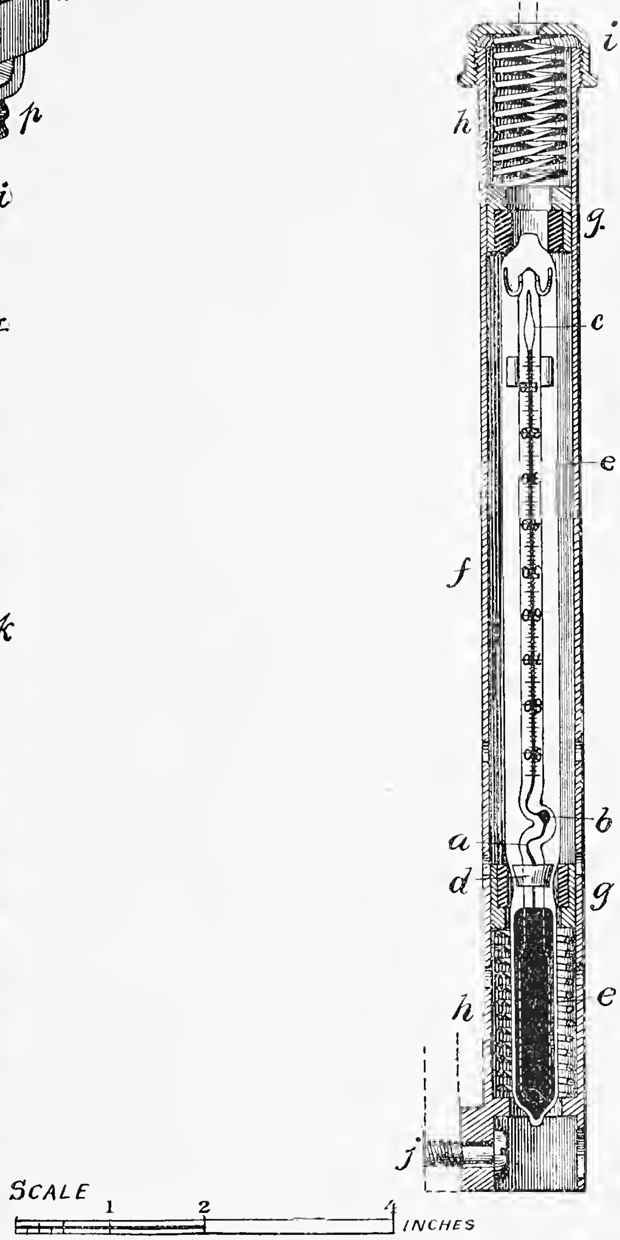


Fig. 2.

THE TANNER IMPROVED THERMOMETER CASE AND SIGSBEE CLAMP, USED WITH THE NEGRETTI & ZAMBRA DEEP-SEA THERMOMETER

Nomenclature.

a. Neck of the bulb.
b. Catch reservoir.
c. Small receptacle.
d. Partition confining mercury in shield surrounding bulb.
e. Glass shield inclosing thermometer.
f. Thermometer case.
g. Thimble with rubber lining.
h. Spiral springs.
i. Cap.
j. Pivot.
k. Slot for reading scale.
l. Frame of cast brass.
m. Guard.
n. Propeller.
o. Spindle.
p. Set screw.
q. Sigsbee clamp.
r. Clamp screw.

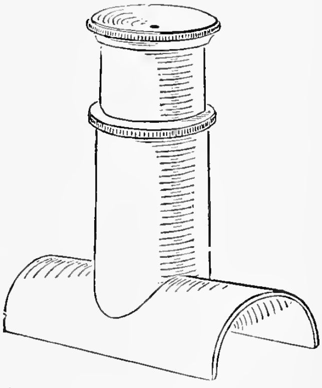
however, the bight of wire between the two jaws of the clamp should be drawn back over the head of the clamp screw *r*, to prevent slipping. The guard *m* is intended for the protection of the propeller against accidental contact with the sounding machine or ship's side.

The method of mounting and protecting the thermometer in its case will be readily understood by reference to fig. 2, where, securely inclosed in its glass shield, it is ever resting in rubber-lined thimbles, which move freely along the inner surface of the case and guard it laterally, while the delicate spiral springs of phosphor bronze protect it longitudinally from the jarring caused by the rapid motion of the reeling engine, which, with the old methods of mounting, sometimes affected the reliability of observations by shaking the mercury down into the tube. The temperature is read through the slot *k* by means of a reading lens. The case is pivoted at *j* in such a manner that it swings freely after it is capsized but can not strike the wire while reeling in.

To take a temperature set the spindle *o* into the hole in the cap *i* by screwing it down until the propeller blades strike the set screw *p*; then, by means of the Sigsbee clamp *q*, secure it to the temperature rope. The bulb will then be down and the mercury in the tube connected with it, the position required to take the temperature. The water acting on the propeller during the descent will keep it in position resting against the set screw *p*, but as soon as the reeling in begins the propeller is set in motion, bringing the screw on the upper end of the spindle into action, gradually raising the propeller until the lower end of the spindle is withdrawn from the hole in the cap *i*, when the thermometer promptly turns over and registers the temperature by breaking the column of mercury at the point *a*, the column then falling to the bottom of the tube. The scale can be read at any time, providing the thermometer has been kept bulb up, as changes of temperature do not affect the reading after the column is once broken.

READING LENS FOR THE TANNER THERMOMETER CASE.

It is a difficult thing to hold a thermometer vertically and exactly opposite the eye, some observers tipping it forward a little, and some backward, with a consequent change in the apparent relative positions of the top of the mercury column and of the scale behind it. Dr. Kidder tested a number of different observers and found that the probable parallax error in reading, by those who use the thermometers in practice, is not far from 0.3°. While this error is of little moment in the ordinary temperature observations in air or at the surface, it assumes greater importance in the deep sea, where variations in temperature are slight, and, to eliminate errors of parallax as far as possible, he introduced a reading lens made by Mr. Joseph Zentmayer, of Philadelphia, which he describes as follows:



CUT 47.—Reading lens for Tanner thermometer case.

The lens is about 3 inches focal length, fitted at right angles to the center of a brass saddle adapted to the convex surface of the thermometer case, and provided with a short draw tube for focusing. The eyepiece opening is made smaller than the pupil of the eye, and there is therefore no variation in the reading, whatever may be the inclination to the perpendicular at which the scale is viewed. The magnifying power of the lens makes it much easier than formerly to read the temperature to fractions of a degree.

THE MILLER-CASELLA DEEP-SEA THERMOMETER.

Plate XXII shows this thermometer in the copper case used for deep-sea work; also partially dismounted to show the form of construction. The magnet seen between the two instruments is used to adjust the indices.

The following description is from Sigsbee's Deep-sea Sounding and Dredging, page 108:

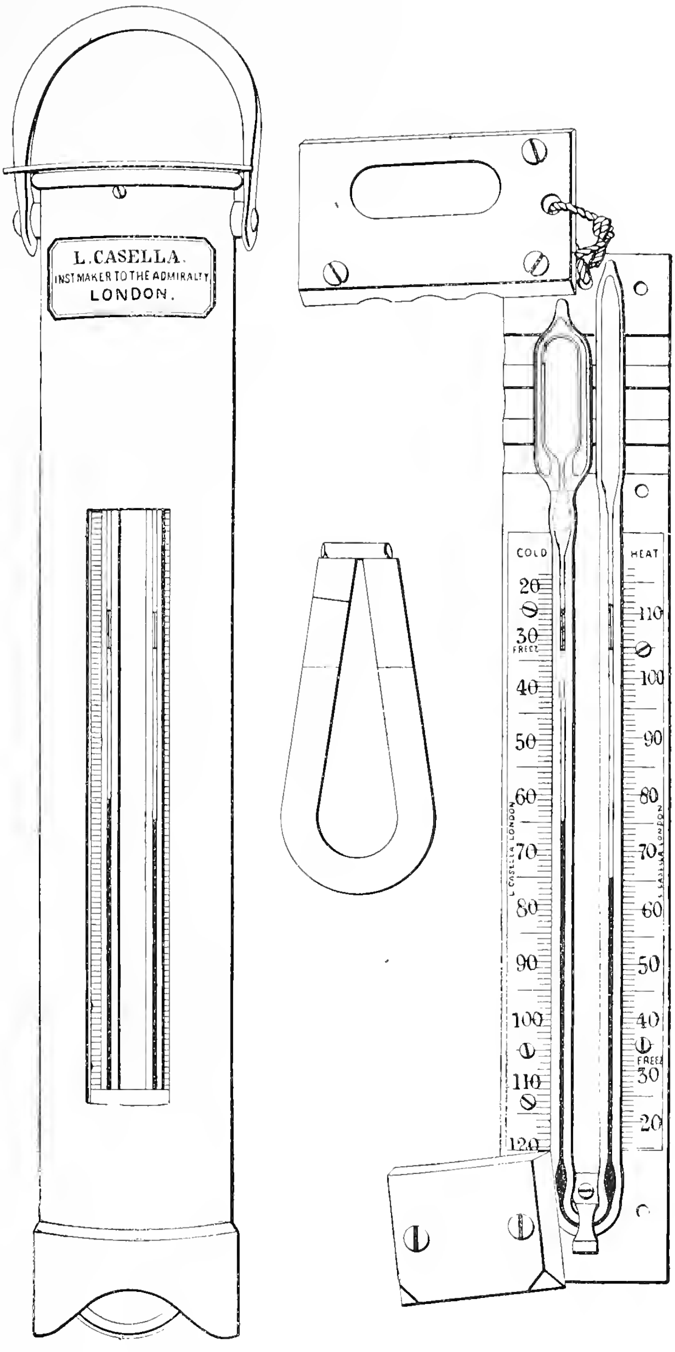
> A glass tube bent in the form of U is fastened to the vulcanite frame, and to the latter are secured white glass plates containing the graduated scales. Each limb of the tube terminates in a bulb. A column of mercury occupies the bend and a part of the capillary tube of each limb.
>
> The large bulb and its corresponding limb above the mercury are wholly filled with a mixture of creosote and water; the opposite limb above the mercury is partially filled with the same mixture, the remaining space therein being occupied by compressed air. In the mixture, on each side, is a steel index having a horsehair tied around it near the upper extremity. The ends of the elastic horsehair, being held in a pendant position by the inner walls of the tube, exert enough pressure to oppose a frictional resistance to a movement of the index in elevation or depression. As thus described, the instrument is a self-registering maximum and minimum thermometer for ordinary use. The indications are given by the expansion and contraction of the creosote and water mixture in the large full bulb.
>
> The instrument is set by bringing the lower end of the indices in contact with the mercury by means of a magnet provided for the purpose. Then, when the instrument is submitted to a higher temperature, the expansion of the mixture in the large bulb depresses the column of mercury on that side and correspondingly elevates it on the other side. A decrease of temperature contracts the mixture in the large bulb, and by the elastic force of the compressed air in the smaller bulb a transference of the column of mercury takes place in precisely the reverse manner to that which occurs on a rising temperature. Thus the mercury rises in the left limb for a lower and in the right limb for a higher temperature. The greater the change of temperature the higher the point reached in the respective limbs; hence the scale on the left is graduated from the top downward, and that on the right from the bottom upward. The rising of the mercury in either limb carries with it the index of that limb, and on the retreat of the mercury the index remains at the highest point attained. The bottom of the index, being the part which has been in contact with the mercury, gives the point at which to take the reading.

The large bulb of this thermometer is now protected from pressure by a glass shield which surrounds it; the space between the shield and bulb is nearly filled with alcohol, which acts as a transmitting medium for temperature, performing the same function as the mercury in the shield of the Negretti & Zambra thermometer. The shield above mentioned has added much to the value of the instrument, as it has practically eliminated errors arising from varying pressures.

This thermometer has been considered the standard for deep-sea work, and when several were to be sent down to great depths on the same line it was unrivaled until the present improvements in the methods of capsizing the Negretti & Zambra thermometers were introduced. It is not as sensitive as the Negretti & Zambra, but under the above conditions a delay of a few minutes is not of great importance.

The movable indices are a fruitful source of annoyance and vexatious delay. An index may, without apparent cause, absolutely refuse to move in the tube; coaxing with the magnet is followed by lightly tapping the frame in the hand or swinging it rapidly about the head, and if this fails more vigorous tapping is apt to follow with various active measures, none of which tend to improve the general condition of the instrument. The indices are also liable to move if the instrument is subjected to rough treatment, although this is not of frequent occurrence with careful handling.

Most of the minor casualties to which the instrument is liable are apparent to the eye and are readily adjusted.

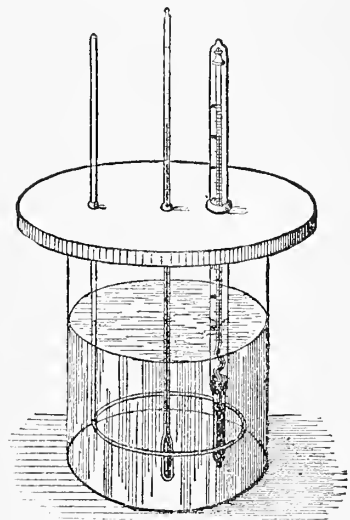


THE MILLER-CASELLA DEEP-SEA THERMOMETER.

KIDDER'S THERMOMETER COMPARISONS AND CORRECTIONS.

Surgeon J. H. Kidder, U. S. N., had charge of the thermometers of the United States Fish Commission from 1883 to 1885, during which time he compared every instrument before it was issued for service. Since then they have been corrected by the United States Weather Bureau. Kidder's methods and appliances were sufficiently simple and effective to serve as a guide for the preparation of similar apparatus on shipboard. The substance of the following is taken from his report on the thermometers of the United States Commission of Fish and Fisheries, 1885. He used two Fahrenheit standards, made by J. Hicks, London, and verified at the Kew Observatory. They were pointed to fifths of a degree, and a good reading could be made to tenths of a degree; they ranged from 10° to 120° F.

A small comparing jar was first used, in which the instruments to be corrected were immersed with the standard. A ring stirrer was provided, and the jar had a wooden cover perforated with suitable holes to allow the instruments to pass through and hold them in place. By agitating the stirrer up and down, the water contained in the vessel was thoroughly mixed and a uniform temperature obtained. This simple contrivance answered very well for ordinary thermometers with bulbs exposed directly to the water, but admitted only two or three instruments at a time, owing to the comparatively small volume of water which it contained. A larger jar with a capacity of 22 gallons was subsequently used.



CUT 48.—Small comparing jar.

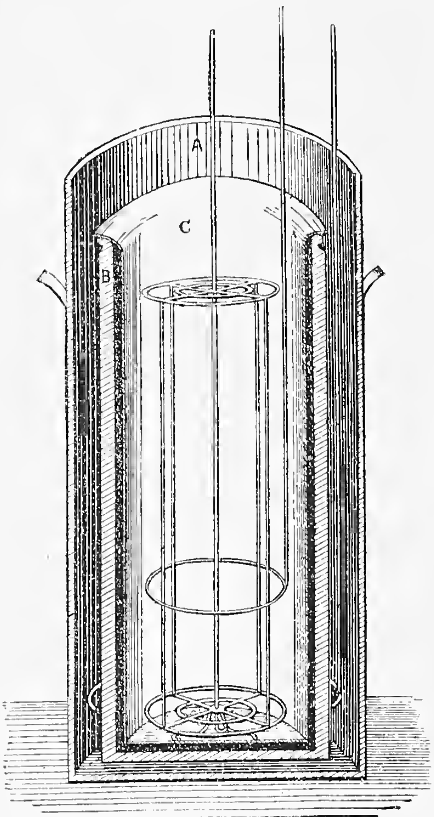
For the "zero point," or 32° F., the thermometers to be tested were immersed in finely-broken ice contained in a large glass percolator, 12 inches wide by 12 inches deep, with a small opening at the bottom for the escape of water as fast as the ice melted. This percolator is supported upon a suitable iron tripod and holds 8 thermometers without crowding.

For deep-sea thermometers, which are protected against water pressure by double glass bulbs and which are therefore slow and require exposure to a constant temperature for at least 10 minutes, Prof. T. Russel's comparing jar was used, a sectional elevation of which is shown in cut 49.

The outer can A is of galvanized iron, 13½ inches high by 11 inches in diameter; B is an earthenware jar, 11 inches high by 8 inches in diameter; C is a tinned copper pot, fitting pretty closely into B and suspended by a flange at the top. Inside of C is a copper frame, movable about a central spindle, to which the thermometers are attached. A ring stirrer moves in the space between A and B, and another between C and the thermometer frame. When the temperatures to be observed are below that of the air, the spaces between A and B and within C are filled with water, that in the outer space being from 5° to 10° colder than that in contact with the thermometers. It is advised that they should be immersed for a time in water near the temperature sought before transferring them to the comparing jar.

By agitating both bodies of water briskly with the stirrers and observing the standard thermometer in the inner jar from time to time, a sensibly constant temperature will at length be reached, at which the gain in temperature of the water in the

inner jar by contact with the warmer air at its surface is very satisfactorily compensated by its loss through the air space between B and C and the badly conducting walls of B. For temperatures higher than that of the air the water in the outer jar must be warmer than that in the inner. No positive rules for differences in the temperatures of the water in the inner an outer jars can be established, yet it may be said, in general terms, that the greater the difference between the temperature of the air and that desired for comparison the greater should be the difference between the temperatures of water in the outer and inner jars.



CUT 49.—Comparing jar for deep-sea thermometers.

To avoid parallax error in reading, the jars were leveled and readings taken by aid of a hand lens, with the eye and top of the mercury column at the level of the top of the outer jar, across the two sides of which the reading is sighted, the thermometer being held in contact with one of the walls of the jar and parallel with the central spindle of the frame to insure its perpendicularity. Comparisons of readings taken in this simple way with readings taken by the cathetometer, the thermometer being secured in a perpendicular position, show no perceptible error. When issued, each thermometer was accompanied by a printed blank corresponding to a stub slip in the rating book and filled out for each point at which a comparison was made.

The following admirable article (pp. 330–336) upon the methods of thermometer correction is kindly contributed by C. F. Marvin, professor of meteorology United States Weather Bureau, and affords valuable information regarding the physical principles involved as well as their practical application in the comparison and correction of thermometers.

NOTES UPON THERMOMETERS AND HOW TO DETERMINE THEIR ERRORS.

A clear understanding of the methods employed in determining the errors of thermometers can not be obtained without a correct conception of the physical principles involved in the measurement of temperature and the action of thermometers in general. The following remarks will therefore preface a description of the methods employed at the United States Weather Bureau for comparison of thermometers:

The several scales of units employed in the measurement of temperatures are all based upon two definite temperatures at which certain simple and easily reproduced physical phenomena invariably occur. The melting of ice formed from pure water furnishes one of these temperatures, called, generally, the freezing point. The second definite point in the scale of temperatures, namely, the boiling point, is established in the temperature of the steam from pure boiling water.

To accurately reproduce a standard boiling-point temperature it is necessary that the escaping steam be subjected to a pressure equivalent to the pressure of a vertical column of pure mercury 760 millimeters high, when its temperature is at the freezing point, and under a gravity equal to that at sea level and at latitude 45°.

The temperature interval between the freezing and boiling points on any thermometric scale is, therefore, established by two definite physical phenomena. The subdivision of the interval into small and convenient units is purely arbitrary and need not be considered here.

The errors to which the ordinary mercury in glass thermometers are subject are the result of three wholly different causes. The sources of errors are:

(1) The inequalities in the diameter of the bore of the thermometer from point to point along the stem. Tubes can not be produced of absolutely uniform diameter, and where the diameter is large, unless compensated for in the graduations, the temperature indicated will tend to be too low, and too high where the bore is narrow. We may include in this source of error any accidental irregularity in the scale of graduations.

(2) The second source of error is found in the character of the expansion of the mercury itself. The amount of increase in volume for a small increase in temperature is not exactly the same at low and high temperatures, and the error due to this cause is further modified by the irregular expansion of the glass envelope. No two kinds of glass will expand in quite the same way.

(3) A third source of error arises from a small, protracted, and gradual shrinkage of the glass in the bulb of the thermometer. Different varieties of glass exhibit marked differences of behavior in this respect. A thermometer heated to the boiling or other high temperature to-day, and which registers correctly when tested at the freezing point will, a month hence, when again tested at the freezing point, often be found to indicate one or two tenths of a degree too high.

It results from the second source of error mentioned above, that, even if a mercury in glass thermometer be constructed with the greatest care, its freezing and boiling points fixed with extreme precision, and its scale of graduations adapted to perfectly compensate for inequalities in the bore, the instrument will yet fail to indicate temperatures correctly, because of the variable rate of expansion of mercury combined with the unknown and more or less irregular behavior of the glass envelope.

It is necessary to have recourse to some other standard for comparison. Fortunately, the expansion of dry air, when free from carbonic acid, or better, of pure, dry hydrogen, is found to be almost perfectly regular over a very wide range of temperatures and is, therefore, capable of being a true index of temperature. The air thermometer, then, is the standard instrument commonly adopted for the measurement of temperature. Its use, however, being a matter of considerable complication, the errors of suitable high-grade mercurial thermometers are determined once for all with great care by extended comparisons with the air thermometer, whereupon the mercurials are available for convenient and frequent use as working substandards representing the air-thermometer scale.

The difference between temperatures on the air thermometer scale and a normal mercury in glass thermometer may amount to nearly two-tenths of a degree at ordinary temperatures and is much greater at temperatures above the boiling point.

It is advisable in all cases that the graduations of mercurial and other similar thermometers be etched on the stem and not engraved on a separate strip of wood or metal, as is often the case.

COMPARISON OF THERMOMETERS.

We determine the error of a thermometer at the temperature of the freezing point by completely covering the bulb and that portion of the stem containing mercury with clean ice shaved up into fine fragments by a jack-plane. This test must be made in a place where the air temperature at the time is above the freezing point, so that the ice will melt steadily. After being exposed to this condition for five or six minutes a reading of the thermometer shows whether or not it is correctly graduated and the amount of any error that may exist.

For any other temperature than freezing, except the boiling temperature, the thermometer to be tested and a standard are placed in a bath of water, if the temperature is above freezing, or of alcohol if below freezing. The liquid being thoroughly stirred so as to render the temperature uniform throughout, a quickly made reading of the two thermometers shows the amount of error in the graduations of the one under test.

When a large number of instruments are to be compared with standards, as is the case at the Weather Bureau, the thermometers are collected together in bunches of 12 each. Only the glass tubes are placed in the bunches, the metal backs of the thermometers being removed during comparison, not only to avoid bulkiness but to prevent the injurious effects and slight corrosion of the metal caused by the water and alcohol baths. The bunches are formed upon flat metal frames adapted to receive six thermometers on each face, front and back, the thermometers being held by rubber bands.

For the freezing-point test a small wooden box 5 inches wide, 4 inches deep, and 18 inches long is employed. To permit the water from the melting ice to escape, the bottom is pierced with irregularly distributed holes 1 inch in diameter and about $2\frac{1}{2}$ inches apart. This box is nearly filled with clean, shaved ice, bunch after bunch of thermometers are placed therein and new ice added and packed closely around each thermometer and piled up above the sides of the box until the bunches are wholly covered, being supported by the ice.

The readings of the thermometers are then made and recorded, the ice being scraped away so as to expose the stems in the vicinity of the ends of the mercurial columns. A small eye-lens is always employed to assist the vision and to insure that the line of sight is exactly at right angles to the stem of the thermometer.

This reading glass consists of a small lens having a focal length of about $1\frac{1}{4}$ inches. It is set in a brass tube $\frac{1}{2}$ inch in diameter and 3 inches long. The lens is about $1\frac{1}{4}$ inches from one end of the tube and the opposite end is closed by a metal cap having a small hole in the center, about one-sixteenth of an inch in diameter. In reading a thermometer the open end of the brass tube is set squarely against the glass stem while the eye sights through the small hole in the cap. The eye estimates fractions of a degree to the nearest tenth, or, if the graduations are halves or fifths of degrees, then the estimation is to the nearest hundredth of a degree.

The tests at the freezing temperature are followed by tests at temperatures 42°, 52°, and so on, for every ten degrees up to 102° or 112°. The apparatus employed consists of two cylindrical copper cans, one within the other. The outer can is 12 inches in diameter, the inner 8.5, and each is 13 inches high. Three feet upon the bottom of the inner can make a space of three-quarters of an inch between the bottoms of the two vessels. The inside vessel is fitted with a light metal frame in the form of

a square, with one side removed and having three prongs or arms with notches at the ends that fit over the rim of the can. The frame is thus supported over the center of the vessel and on a level with its top. Two bunches of thermometers may be placed within the open square, the sides of which are provided, in addition, with several holes three-eighths of an inch in diameter, through one of which is placed the working substandard, as may be most convenient for use during comparisons. A short fragment of small rubber tubing slipped over the stem of the substandard prevents it from passing entirely through the relatively large hole in the frame and permits placing the bulb of the substandard at the same depth in the can as those of the bunched thermometers. These latter are submerged to within about one-half inch of the top of the stem.

The two cylindrical vessels are not fastened, the one to the other. The smaller sets loosely but about centrally within the other. Each is fitted with a dasher for effectually stirring the water, with which both vessels are filled brimming full. These dashers consist of annular brass plates fitted with an upright rod of brass attached at one side and reaching just above the top edge of the vessels, respectively, where a large thumbscrew head is attached that facilitates grasping the dasher. The dasher in the outer vessel traverses the annular space between the two; that within the smaller vessel encircles the bunched thermometers hanging in the center. The comparator is placed within a shallow tray of the photographer's type, to retain the water which may accidentally slop over.

The comparisons require the services of two persons—the observer and the recorder.

The numbers of the twelve thermometers constituting a bunch are recorded in the record book of observations in two groups of six numbers each, representing the six thermometers on one face of the bunch. An additional space in each group contains the number of the substandard used in the comparison, and the two groups are classed together under a number corresponding to that stamped on the metal plate of the bunch; the side bearing the number is the front, the other is the back.

The comparisons, for example at 42°, are made as follows: Two bunches of thermometers and the substandard are placed in the bath. Ice in small fragments is added to the water until the temperature is less than half a degree above or below 42°. A slight excess of ice is allowed to remain, and if the room in which the comparison is made is comfortably warm the temperature of the water in the outside vessel is regulated to be 1° or 2° lower than that of the inside vessel, in order to lessen the tendency of the temperature of the baths to rise.

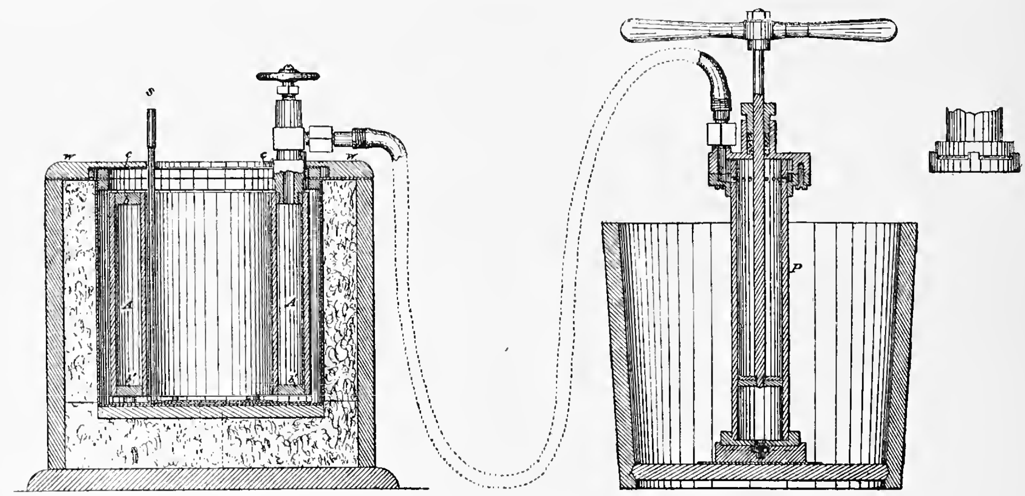
The water is stirred actively by hand, and when the temperature, by a few preliminary readings of the substandard, is seen to change very little the stirring is suspended, a careful reading of the substandard is made and recorded, and immediately followed by recording the readings of the six thermometers on the face of the first bunch, which is lifted in the water a little so as to expose the tops of the columns. The bunch is turned back to the front, the water thoroughly stirred, the substandard and the six thermometers on the back of the bunch read and recorded. The bunch is removed from the water, which is again stirred, and readings of the second bunch are made and recorded in precisely the same manner.

When special accuracy is to be attained the readings at each temperature are repeated as many times as may be desired.

The temperature of the water baths is increased by replacing a portion of their contents, withdrawn by a siphon, with hot water.

When comparisons are made at temperatures below freezing, the low-temperature comparator has been found to answer all requirements in a most admirable manner, and has been used to produce temperatures as low as 65° F. below zero. Still lower temperatures, it seems, are easily obtained, though up to this time no occasion to go to lower temperatures has arisen.

The annular iron flask A is made of the best iron boiler-flue tubing, strongly fitted with the headpieces *b b'*. The outside diameter of the two tubes is, respectively, 6 and 9 inches, the flask being 9 inches high and containing about 1 gallon. The whole stands within a copper can, itself placed within a larger wooden jacket, the interspace being filled with cotton. A top plate of metal, *c c*, partly covers the can, to which it is tightly screwed, leaving a circular opening at the center of about the same diameter as the inside of the flask A. The whole is again covered, except the opening, by a loosely fitting wooden plate, *w w*. The alcohol with which the can is filled can be



CUT 50.—Low-temperature comparator.

stirred in a most thorough manner by means of a disk dasher, S, moving near the bottom of the can and within the iron flask. This passes the alcohol in a rapid manner from the inner portion to the outside around the iron flask and vice versa, with the most satisfactory results.

The iron flask, by means of the screw-threaded outlet of its valve, can be joined by a very short piece of pipe to a flask of ammonia, which, in this case, must always be upside down in order to run off the liquid. If the flask A contains air, generally only a small quantity of liquid ammonia will enter, and this is best effected by opening the valves quite promptly. To further charge the flask it is first necessary to drive out the air, for which the stock ammonia flask is disconnected and a rubber tube or other outlet attached. The ammonia in the gaseous state, when permitted to escape from A, carries with it the air also. The temperature of the alcohol is gradually lowered, and if an additional supply of ammonia is needed any quantity may be drawn from the supply flask out of which the ammonia will now be strongly forced by its greater vapor pressure, due to the difference of temperature of the two flasks. The ammonia gas is best disposed of by passing it into a bottle or other vessel of water, which is thus, in time, converted into excellent aqua ammonia.

One can judge of the quantity drawn off only by the sound and such circumstances. A note, however, is always kept of the weights of the stock flask, giving not only how much has been withdrawn, but its present contents as well. Between 4 and 5 pounds of ammonia are sufficient to lower the temperature to —65° and work at various intermediate temperatures for several hours. The temperature can be readily lowered to any point down to —20° F., simply using the rubber tube and water vessel. At this point, however, the escape of the ammonia gas is slow, owing to its diminished pressure. The pump shown at P is then brought into requisition. The diameter of the barrel is nearly 3 inches and the construction is somewhat peculiar, there being but one valve. Connection with the flask A is made at the top of the pump, the communication with the inside being through the small holes near the top of the cylinder. The piston when in its highest position is above these holes. At the bottom of the cylinder is a large, flat valve, closing upward with gentle pressure. From the valve way the passages to the outside are seen in the side view of this portion of the pump. The valve itself is pierced with a small hole of only about one-sixteenth inch diameter, and the whole pump is securely fastened inside a bucket or similar vessel nearly filled with water, which makes its way into the pump through the small hole in the valve; in some cases of low inside pressure quite a fountain-like jet of water is formed. With the piston in its highest position the ammonia has free communication to the pump cylinder and is rapidly absorbed by the water which is readily renewed by emptying the cylinder with a stroke of the piston. The absorption of the ammonia by the water is very vigorous generally, and the number of strokes of the pump necessary to dispose of a comparatively large volume of gas is correspondingly small.

The pump is remarkably effective, though when not in action the piston must be secured in a lowered position in order to prevent the rise of heated water into the tube and possibly the flask A, though the valve of the latter is generally kept closed when the gas is not being drawn off. During the escape of the gas the flask and its contents are always noticeably colder than the alcohol, so that it is easy to secure very nearly a stationary temperature of the latter for several minutes, shortly after the valve is closed.

Except as otherwise specially mentioned all measurements of the differences in level of the mercurial columns were made with a most excellent and substantial cathetometer made some years since by the Société Genevois. The vertical bar is a cylinder supported on sharp cones at both top and bottom. The two telescopes are each fitted with excellent micrometer eyepieces. Only one of these was used, and its micrometer screw was examined for errors, which were found so small as to be quite unimportant, and no correction for this was necessary. Except in the very first work the distance of the manometer tubes from the objective was 359 mm., and the micrometer reticule was 349 mm. from the objective. The image, therefore, is about the same size as the object.

Many determinations of the value of one division of the micrometer were made during the progress of the work, with only very slightly different results. One division corresponded almost exactly to 0.005 mm., and this could be subdivided to tenths by estimation.

The value of one division of the telescope level was nearly three seconds. The level was at all times carefully watched and sometimes recorded, but corrections for

errors of this kind were always unnecessary, as the cathetometer in this respect, as in all others, has proved to be a most perfect instrument.

The comparisons of special forms of thermometers require slight modifications of the processes that have been described.

Alcohol thermometers are much slower in changing temperature than mercurial thermometers, both on account of the less conductivity of the liquid and because of the adhesion of liquid to the walls of the stem. Time must be allowed for the liquid to drain down when observations are made under conditions of falling temperature.

Maximum thermometers are not as a rule compared below freezing, and require a special apparatus for whirling them while packed in ice. The temperature of the water baths should be allowed or caused to gradually increase while comparing maximum thermometers.

The upsetting deep-sea thermometers, owing to the peculiar construction of the bulb, require prolonged exposure in ice; about a half hour is allowed, to make sure that the bulb is at a true freezing temperature. The bunches of these thermometers contain only six instruments, three on a side. The bunch is upset while still packed with ice, which is then partially removed for reading. At other temperatures only one large vessel of water is used. After about five minutes exposure to a stationary temperature, the water being thoroughly stirred, the substandard is read, the bunch upset in the water, and readings made and recorded.

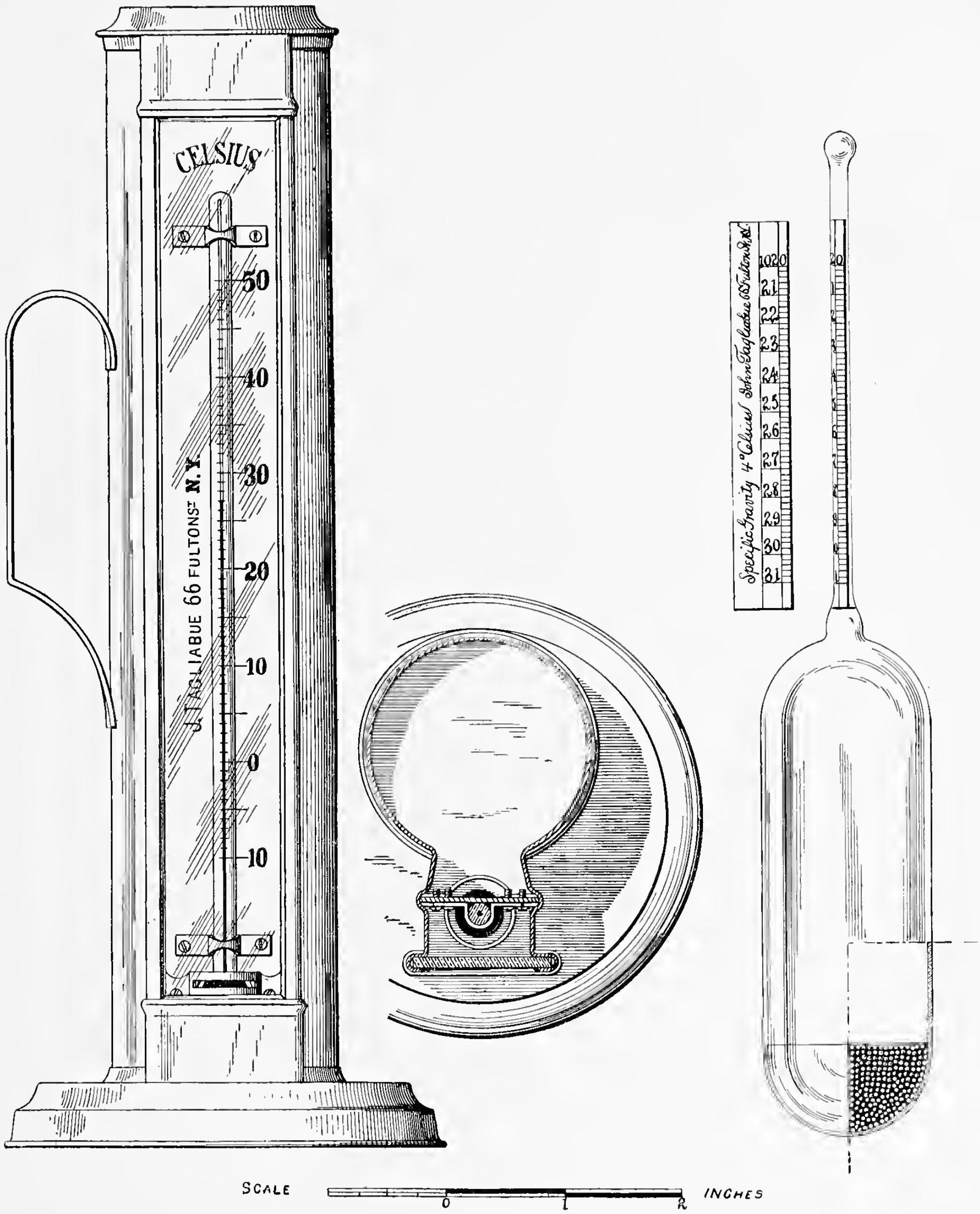
REDUCTION OF OBSERVATIONS.

Each substandard, after comparison with the air thermometer, is provided with a table of normal corrections, but these for convenience are computed on the supposition that the correction at the freezing point is 0.0°, for the reason that, as already pointed out under "A third source of error," on page 331, the correction at the freezing point is apt to change from time to time, especially after the substandard has been used at some high temperature, say 130° F., or more. When any doubt exists as to what corrections to apply to the indications of the substandard, it should be tested at the freezing point. Suppose we find the thermometer reads 0.23 of a degree too high, the true correction at the freezing point is therefore −0.23°, and this amount must be algebraically added to each correction given in the table of normals.

The recorded readings of the substandard being corrected by the application of the corrections found in the above manner, we have the true temperature of the water according to the air-thermometer scale during the several comparisons. The correction of a thermometer at the temperature of one of these observations is the quantity which must be *algebraically added* to its reading in order to make the reading indicate the true temperature of the water, that is, to make the reading agree with the corrected reading of the substandard.

Thermometers require recomparison from time to time, but only at the freezing point. Whatever change in the correction is found necessary at this point must also be made in each of the other corrections found in the original comparisons. This is explained in the remarks about the corrections to be used with the substandard.

When a greater or less portion of the mercurial column in the stem of the thermometer is exposed to a different temperature than the bulb, the indications are slightly in error and a correction should be applied. This is sometimes necessary in the use of long substandards. It is to be avoided as far as possible.



THE HILGARD OCEAN SALINOMETER.

DENSITY OF SEA WATER.

The density of sea water in different latitudes and at different depths is an element of so great importance in the study of ocean physics as to have caused a great deal of attention to be paid lately to its determination. The instruments employed for the purpose have been, almost without exception, areometers of various forms. The differences of density as arising from saltness are so small that it is necessary to have a very sensitive instrument. As the density of ocean water at the temperature of 15° C. only varies between the limits 1.023 and 1.028 it is necessary, in order to determine differences to the hundredth part, that we should be able to observe accurately the half of a unit in the fourth decimal place. This gives a great extension to the scale and involves the use of a series of floats if the scale starts from fresh water, or else the instrument assumes dimensions which make it unfit for use on board ship.

With a view to the convenient adaptation to practical use, a salinometer (plate XXIII) was devised for the Coast Survey by Prof. J. E. Hilgard, which was subsequently adopted for use on board the vessels of the United States Fish Commission. Fahrenheit thermometers were used, and the densities given by the graduation of the hydrometer were referred to pure water at 60° F. The centigrade scale was adopted by the Coast and Geodetic Survey and by the United States Fish Commission in 1890, and all hydrometer observations since then are referred to that scale, the densities being reduced to the temperature of 15° C. referred to pure water at 4° C.

Hilgard's ocean salinometer is composed of a series of cylindrical glass floats numbered 1, 2, and 3, respectively, their bodies $4\frac{1}{2}$ inches in length by $1\frac{1}{4}$ inches in diameter, the stems $4\frac{1}{2}$ inches in length and $\frac{3}{16}$ inch in diameter, the scales being marked on the interior of the stems. The range of No. 1 is from 1000, or fresh water, to 1011; No. 2 from 1010 to 1021, and No. 3 from 1020 to 1031, which gives sufficient range from fresh water to salt, including the effect of temperature. Each unit in the third place, or thousands of the density of fresh water, is represented by a length on the stem of 0.3 of an inch, which is subdivided into five parts, admitting of an accurate reading of a unit in the fourth place of decimals by estimation.

The vessel for holding the specimen of water is of copper, cylindrical in form, $9\frac{3}{4}$ inches in length and $1\frac{7}{8}$ inches in diameter, with a base of $3\frac{3}{4}$ inches. The water cup itself is $8\frac{7}{8}$ inches long and $1\frac{7}{8}$ inches in diameter. The attached thermometer is inclosed within a water-tight, glass-faced frame, secured to the cylindrical body of the cup, a section of the latter being removed to allow free circulation of water between its interior and the thermometer. The temperatures are read through the glazed front. The floats are packed separately in $1\frac{3}{4}$ by $10\frac{3}{4}$ inch tubes or cylinders of tin, in which they are protected by cotton, and the stems have additional protection of hollow, cotton-lined, wooden sleeves, which envelop them, slip inside of the tin tubes, and impinge upon balls of cotton, with which their covers are lined.

A working set of three floats and a cup, the former in their tubes of tin, are packed in neatly fitting woolen-lined apertures in a handy wooden box 11 inches long, 10 inches wide, and 4 inches high, inside measurement. Spare floats are also provided with tin tubes, in which they are always packed, either for transportation or stowage.

To observe the specific gravity of a specimen of sea water, fill the cup, clean and dry the float, lower it carefully into the water, causing it to overflow from the top of the cup, and, when the float has come to a rest, read off the scale at the surface of the water, not from the water immediately surrounding the stem, where it is slightly elevated by the effects of capillary attraction; note temperature of water by attached thermometer, and correct observed density by means of subjoined table.

As before stated, the variation in specific gravity of sea water is so small that the greatest accuracy is required to give value to observations, and experience alone will teach the observer how difficult it is to obtain satisfactory results on shipboard when the vessel is under way, particularly if there is much motion. In order to avoid this fruitful source of error, a supply of the best quality of glass bottles, with ground-glass stoppers, were procured from the manufacturers, C. Dorflinger & Sons, who describe the material as follows:

> This grade of glass is what is called "lead glass" and has been made especially for the work of the United States Fish Commission and the National Museum. It is a glass that is very suitable for making specimen jars and work of this character, and is composed of sand, red lead, pearl ash, nitre, arsenic, and manganese. The quantity of arsenic is so small that it burns out in the melting and there is no trace of it in the glass, neither is there anything in it that sea water will affect.

The water specimens are carefully sealed in these bottles until calm, smooth weather, or till the vessel reaches port, when the temperature of the specimens is brought as nearly to the required standard of 15° C. as convenient and the densities carefully observed. It has been said that the stoppers might not be tight, foreign substances might be accidentally introduced into the bottles, or that the sea water might attack the material of the glass itself, thereby changing the specific gravity, all of which might have happened had not proper precautions been taken.

In the first place, the quality of glass is proof against the action of sea water, at least for the short space of time the specimens are exposed; the bottles are carefully cleansed and dried before using, and they are sealed with as much care as though they contained volatile matter. The water specimens are retained no longer than necessary, usually from a day to a week, never more than two weeks, and the densities are observed with great care, under the most favorable conditions.

Rear-Admiral Makaroff, Imperial Russian navy, author of Le Vitiaz et l'Ocean Pacifique, St. Petersburg, 1894, and one of the highest authorities on the specific gravity of sea water, thought the salinometer cup was too small, but his opinion was based upon a casual inspection only, as he had never seen it in operation. Its adoption by the United States Coast Survey and Fish Commission was upon the approval of the most eminent physicists in the United States, and it has been in constant service for many years without eliciting unfavorable comment in a single instance; on the contrary, it has been commended in the highest terms as the most simple and thoroughly practical appliance ever introduced for the purpose.

The table for the reduction of observed densities to 15° C. is taken from Dittmar, Physics and Chemistry, Challenger Expedition, vol. 1, after applying to his densities one-half of the correction given by him for reducing them to Thorpe and Rucker's results. The temperature at which the density of standard water is 1.02600 has been shifted from 15.56° to 15° C. for the sake of getting an integer number. The table has been rearranged so as to give the densities of the standard water multiplied by 1000, for whole degrees and tenths from 0° to 30.9° C. on one page. The values given should have the figures 10 prefixed; these are omitted for brevity's sake. Thus in the table the density for 2.5° is printed 27.92, but this must be understood to mean 1027.92.

The ratio designated $\varphi(t)$ by Dittmar is omitted, and only its reciprocal is given in the column headed m. The values there given appertain to the temperatures on the same horizontal lines given in the first column. The use of this function is illustrated in the examples in which it appears as a multiplier for the purpose of allowing for the different rates of expansion between standard water and the water the density of which is being determined.

The last column has been added to this table for convenience, and gives the correction for change in the volume of the hydrometer itself. The values given have been computed for the mean reading 1026, and with the assumed coefficient of cubical expansion for glass $a = .000025$.

Table for reducing densities of sea water to 15° C.

°	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9	m	a
0	28.08	28.07	28.07	28.06	28.06	28.05	28.04	28.04	28.03	28.03	.951	+0.38
1	.02	.01	.01	.00	.00	27.99	27.99	27.98	27.97	27.97	.955	.35
2	27.96	27.96	27.95	27.94	27.92	.92	.91	.90	.89	.88	.960	.33
3	.87	.87	.86	.85	.84	.83	.82	.81	.80	.79	.963	.30
4	.78	.77	.76	.75	.74	.72	.71	.70	.69	.68	.967	.27
5	.67	.66	.65	.64	.63	.61	.60	.59	.58	.57	.970	.25
6	.56	.55	.53	.52	.51	.50	.48	.47	.46	.44	.973	.23
7	.43	.41	.40	.38	.37	.35	.34	.32	.31	.30	.976	.20
8	.28	.26	.25	.23	.22	.20	.19	.17	.16	.15	.980	.17
9	.13	.11	.10	.08	.07	.05	.03	.02	.00	26.98	.983	.15
10	26.97	26.95	26.93	26.92	26.90	26.88	26.86	26.84	26.83	.81	.986	.13
11	.79	.77	.75	.74	.72	.70	.68	.66	.65	.62	.989	.10
12	.61	.59	.57	.55	.53	.51	.49	.47	.45	.43	.992	.08
13	.41	.39	.37	.35	.33	.31	.29	.27	.25	.23	.995	.05
14	.21	.19	.17	.15	.13	.10	.08	.06	.04	.02	.997	.02
15	.00	25.98	25.95	25.93	25.91	25.88	25.86	25.84	25.82	25.79	1.000	.00
16	25.77	.75	.72	.70	.68	.65	.63	.61	.59	.56	1.003	−0.02
17	.54	.52	.49	.47	.45	.42	.40	.38	.35	.33	1.005	.05
18	.30	.27	.25	.22	.20	.17	.14	.12	.09	.07	1.007	.08
19	.04	.01	24.99	24.96	24.94	24.91	24.88	24.86	24.83	24.80	1.009	.10
20	24.78	24.75	.73	.70	.68	.65	.62	.60	.57	.54	1.011	.13
21	.52	.49	.47	.44	.41	.39	.36	.33	.30	.28	1.013	.15
22	.25	.22	.19	.16	.13	.10	.08	.05	.02	23.99	1.015	.17
23	23.96	23.93	23.90	23.87	23.84	23.82	23.79	23.76	23.73	.70	1.018	.20
24	.67	.64	.61	.58	.55	.53	.50	.47	.43	.40	1.020	.23
25	.38	.35	.32	.29	.26	.23	.20	.17	.14	.11	1.022	.25
26	.09	.06	.03	23.00	22.97	22.93	22.90	22.87	22.84	22.81	1.024	.27
27	22.78	22.75	22.72	22.68	.65	.62	.59	.56	.53	.50	1.026	.30
28	.46	.43	.39	.36	.33	.29	.26	.23	.20	.16	1.027	.33
29	.13	.10	.06	.03	.00	21.96	21.93	21.90	21.87	21.84	1.029	.35
30	21.80	21.77	21.73	21.70	21.67	.63	.60	.57	.54	.50	1.031	.38

The following directions are given to facilitate the use of the table: The observed specific gravity having been taken, record the actual reading of the hydrometer and thermometer, and apply the correction to the latter to get the true temperature t. To the reading of the hydrometer apply the correction a, for expansion of hydrometer, according to its sign, which will give the observed density at $t = \mathrm{OD}$. The density of standard sea water at $t = \mathrm{SD}$, and the difference between observed density and density of standard water at $t = \mathrm{OD} - \mathrm{SD}$, being multiplied by the tabular multiplier m, and the quotient applied to standard sea water at 15° C., according to its sign, gives the corrected density of the sample water at 15° C.

Example I.	Example II.	
°	°	
23.0	10.5	obs. temp.
—0.1	—.2	corr. to thermometer.
22.9	10.3	corrected temp. $= t$.
1021.00	1029.29	observed hydr. reading.
—0.20	+.12	corr. for expansion of hydr. $= a$.
......	......	corr. for hydrometer constant.
1020.80	1029.41	observed density at $t =$ OD.
1023.99	1026.92	density of standard water at $t =$ SD.
—3.19	+2.49	OD — SD.
1.018	.987	m, tabular multiplier.
—3.25	+2.46	m (OD—SD).
1026.00	1026.00	standard water at 15° C.
1022.75	1028.46	corrected density at 15°.

For observations which have been reduced to 60° F., made with the old hydrometers indicating densities referred to pure water at 60° F., it will suffice to subtract the constant 0.82 from the result in order to convert the latter into absolute densities at 15° C.

Example: Given 1024.00, the density of salt water at 60° F. referred to pure water at 60° F., 1024.00—0.82=1023.18, its density at 15° C.

The above plan of decimal notation in Examples I and II, also in the table, is adopted for the sake of simplicity and convenience. The corrected densities will, however, be recorded in the customary manner, as follows: 1.02275 — 1.02846.

The remarks on reduction of observed densities, the illustrative examples, and table for reducing densities of sea water to 15° C. are taken from Bulletin No. 18, United States Coast and Geodetic Survey.

SIGSBEE'S WATER-SPECIMEN CUP.

The Sigsbee water-specimen cup (plate XXIV) or water bottle is designed to bring a specimen of water from any desired depth for the purpose of analysis or to determine its specific gravity. The valves are closed mechanically and can not be opened again, except by hand. Therefore these cups may be used in series, any desired number being sent down on the same line. The water bottle is made of brass, except such parts as are mentioned as being made of other metals. The following remarks upon its working are taken from Sigsbee's Deep-sea Sounding and Dredging, page 93.

To adjust the valves hold the upper valve firmly, and unseat the lower valve by screwing it upward, the key (fig. 5) being applied to the lower end of the valve stem *f* for the purpose. Then maintaining the upper valve on its seat with the finger, or, better, by turning the screw cap down upon it, reseat the lower valve gently. In general it will be necessary to adjust the valve only after the cup has been taken apart for cleaning or other purposes.

The cup when in use comes to the surface filled with water, the screw cap pressing upon the upper valve, thus securing both valves, and the propeller resting upon the screw cap. To remove the specimen from the cup first lift the propeller, and by giving it a few turns cause its threads to engage the screw threads on the shaft; then turn up the screw cap until it uncouples. With the cap in this condition the valves may be lifted and the water discharged. When the screw cap is pressing upon the upper valve, the threads inside the former are engaged with the threads of the shaft, but on screwing up the cap, when its lower thread clears the upper thread of the corresponding series on the shaft, the cap is uncoupled, which prevents any mistake being made at this point by the person handling the cup; afterwards the screw cap may be turned in the same direction indefinitely without jamming or changing its position on the shaft.

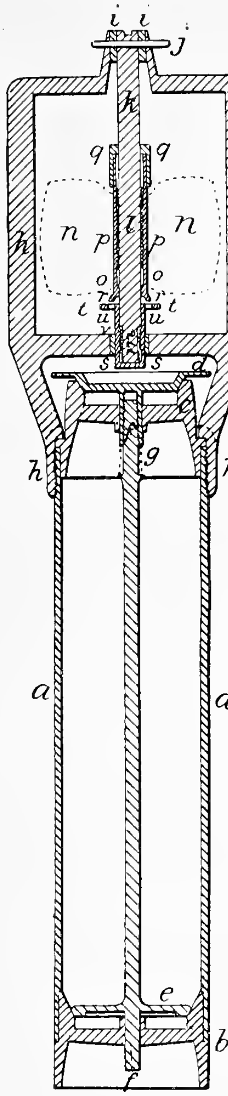


Fig. 1.

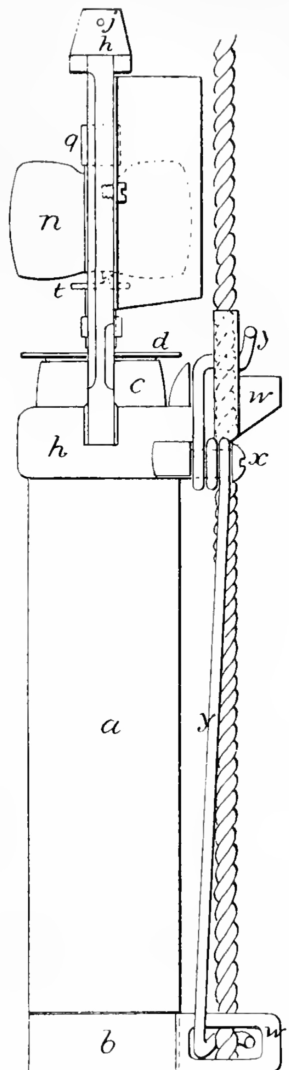


Fig. 2.

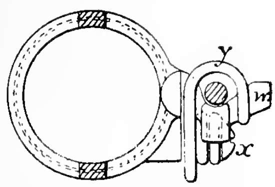


Fig. 4.

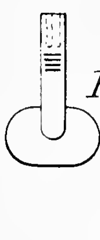


Fig. 5

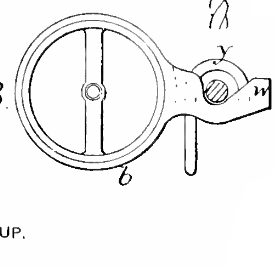


Fig 3.

THE SIGSBEE WATER SPECIMEN CUP.

Nomenclature.

a. Cylinder.
b. Lower valve seat.
c. Detachable upper valve seat.
d. Upper poppet valve.
e. Lower poppet valve.
f. Valve stem.
g. German silver compression spring.
h. The frame.
i. German silver removable sleeve.
j. Brass pin.
k. German silver shaft.
l. Screw thread (44 to the inch).
m. Screw thread (44 to the inch.)
n. German silver propeller.
o. Hub.
p. Inside screw thread (44 to the inch).
q. Guide cap.
r. Beveled lugs.
s. German silver bushing.
t. German silver screw cap with milled head.
u. Beveled slots.
v. Inside screw thread.
w. Clamp lugs.
x. Clamp pivot screw.
y. Phosphor bronze clamp wire.

With the screw cap up and the propeller in any position, the cup is automatic, and may, if desired, be lowered into the water with no other preparation; yet it is a good practice first to screw up the propeller by hand to observe if the threads are in perfect working order. Assuming the propeller is to be low down on the shaft, or even resting upon the screw cap, the action of the water is as follows:

As it descends, the valves are lifted and held up by the resistance of the water; by the same agency the propeller is revolved and carried upward until, like the screw cap, it is uncoupled, after which it revolves freely on the shaft, impinging against the German-silver sleeve *i*. If the propeller hub is allowed to come in contact with the sleeve while the screw threads are still engaged, it may remain impacted during the subsequent ascent. To insure uncoupling at the proper time the guide cap, which fits over the top of the hub, must be set well home in its position, when the propeller is fitted to its shaft. It will be noticed that the blades of the propeller are bent along their upper edges. With the blades thus bent, and all parts of the propeller made very light in weight, it has been found experimentally that the alternating movement of translation imparted to the submerged cup by the vessel's motion in a seaway will cause the propeller, when engaged with the threads on the shaft, gradually to screw up rather than down. This shows that stoppages in the descent, whether to attach additional cups to the rope or wire, or for any purpose whatever, may be made with safety if the vessel is kept idle in the water, that is, without headway or sternboard. Were the blades not bent it is evident that the propeller would gradually screw down by the same alternating movement, since its weight would assist its action in screwing down, but resist the opposite motion. Even thus experiments have shown that with the alternating movement continued for a longer time than would probably be occupied by any stoppage, the propeller would screw down on the shaft only a small proportion of the distance to the screw cap. It is plain that in the event of such action the propeller would rise and uncouple each time the descent was continued. However, the bending of the blades insures safety, and the valves are left free to open during the whole descent. At any stoppage in the descent each cup contains within its cylinder a specimen of the water from its locality at the time being, allowing a margin of 1 or 2 feet.

As soon as the ascent is begun, the valves of each cup are pressed firmly on their seats by the resistance of the water, and each propeller begins to screw down along its shaft under the same influence. When the upper thread inside the hub of the propeller clears the lower corresponding thread on the shaft, the propeller uncouples and drops upon the screw cap, which it clutches. The screw cap is then carried down until it comes in contact with the upper valve, from which position it can not be removed by the action of the water or of the propeller. Both valves being thus locked, stoppages may be made thereafter during the ascent without risking the identity of the inclosed specimen of water.

The distance through which the cup must pass, in order that the propeller may traverse the shaft and lock the valves, may be varied by altering the pitch of the propeller. As shown in the drawing, the propeller would probably not perform its work short of 50 fathoms. I settled on about 25 fathoms as the distance most convenient. With this distance it would not be prudent to require the uppermost cup to bring a specimen from nearer the surface than 50 fathoms. If the propellers were arranged to lock the valve in an ascent of about 25 fathoms, and the uppermost cup were lowered only to a depth of 10 fathoms, for instance, obviously when that cup had arrived at the height of the vessel's deck the submerged cups, having passed through a distance of only about 12 fathoms, would not have become locked. Each cup, as soon as discharged, should be thoroughly rinsed in fresh water.

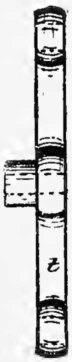
We have found these bottles to work satisfactorily for the purpose of collecting water specimens for specific-gravity determinations; but they will not retain the gases, and are therefore not available for collecting specimens for chemical analysis.

Experience has taught that it is advisable to reset the valves whenever the bottles are to be used, as their adjustment is liable to be impaired in releasing the screw cap from contact with the upper valve. Although Sigsbee states in the remarks quoted that the upper valve seat is detachable for purposes of cleaning, we find in practice that the accumulation of verdigris on the screw threads makes its safe removal impracticable. The valves and valve seats can be readily cleaned, however, without detaching the upper valve seat.

THE KIDDER-FLINT WATER BOTTLE.

The Kidder-Flint water bottle (plate XXV) is designed to bring up a specimen of water from any desired depth, retaining the free gases for the purpose of analysis. The valves close mechanically when the ascent is begun, and can not be opened again except by hand. Therefore it may be used in series.

All parts of this water bottle are brass, except the propeller blades, which are of German silver. The cylinder is a tube of commercial pattern; the frames, valves, valve seats, etc., are cast brass.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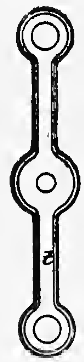
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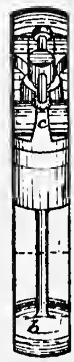
53.


54.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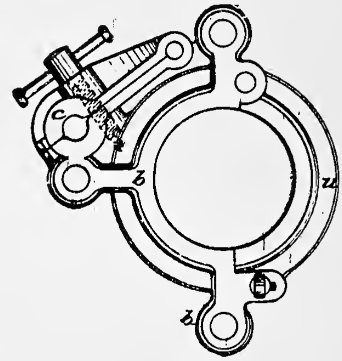
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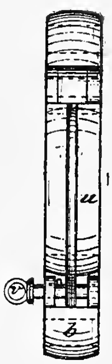
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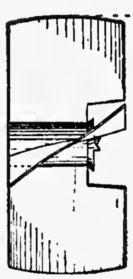
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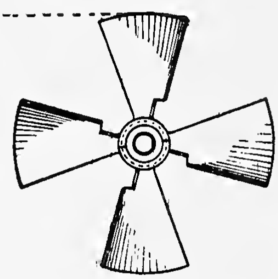

60.

CUTS 51 and 52.—Side and bottom view of outer arms of propeller frame.
CUTS 53 and 54.—Side and bottom view of inner arms of propeller frame.
CUT 55.—Side view of frame *b*, showing clamp *c*.
CUT 56.—Front view of frame *b*, clamp *c*, and clamp *u*.
CUT 57.—Side view of frame *b*, clamp *u*, and pin *v*.
CUT 58.—Side view of sleeve *i* and front view of beveled slots *k k*.
CUT 59.—Side view of propeller, showing beveled lugs.
CUT 60.—Bottom view of propeller.

Preparation for use.—Cleanse the inside of the cylinder from all foreign substances, particularly verdigris, oil, or red lead, which is sometimes used for making joints. Clean the valve faces and valve seats with a soft cloth, avoiding brick dust, emery paper, or other scouring substances, as the valves are very carefully ground in, and any scratch on their faces renders them liable to leak. The valve seats should be removed for cleaning and replaced again, using spanners in the holes *o p* for the purpose, and to insure tight joints without undue strain a little red lead may be used on the shoulder between *m* and *n*. In cleaning the cylinder particular attention should be given to the cock *e* and expansion chamber *d*.

The propellers should be examined to see that they work freely on the sleeves and the supporting screws on their outer extremities. The shafts should be run up

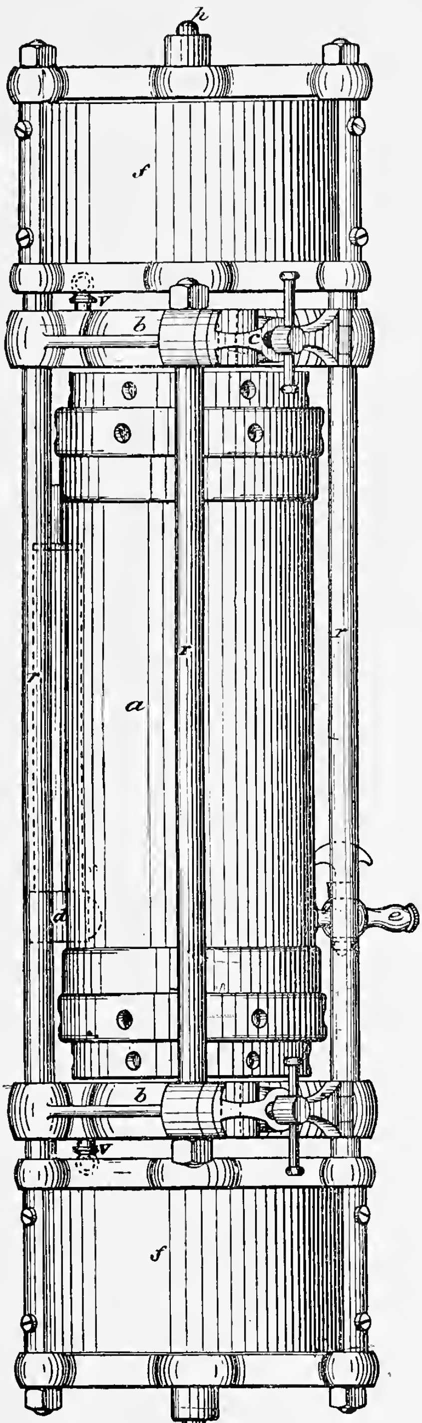
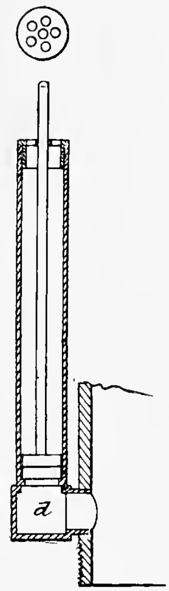


Fig. 1.



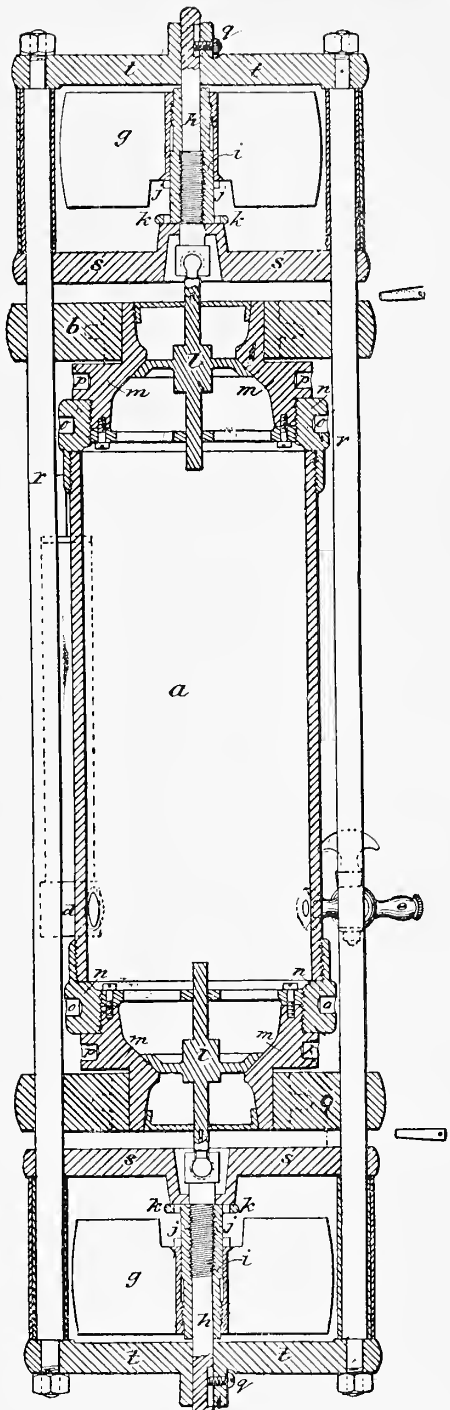


Fig. 2.

THE KIDDER-FLINT WATER BOTTLE.

Nomenclature.

a. Cylinder.
b. Frame.
c. Clamps to secure apparatus to temperature rope.
d. Expansion chamber.
e. Cock.
f. Guards.
g. Propellers.
h. Shafts.
i. Sleeves.
j. Lugs.
k. Slots.
l. Valves.
m. Valve seats.
n. End pieces.
o. Spanner holes.
p. Spanner holes.
q. Set screws.
r. Stay rods.
s. Inner arms of propeller frames.
t. Outer arms of propeller frames.
u. Cylinder clamp.
v. Pin for cylinder clamp.

and down by means of the milled heads at k, to ascertain if the screw threads work freely and the shafts move on their bearings without undue friction.

The propellers should then be moved outward until they clear the supporting screws, where they will revolve freely during the descent without moving the shafts or in any way affecting the valves. The shafts should then be screwed inward a little to allow free connection with the valve stems l.

The cylinder may now be placed in the frame b, the valve stems l connected with the shafts h, and the cylinder secured in place by the clamps u and the pins v. The valves should then be opened inward to their full extent by means of the milled head at k. Secure the bottle to the rope by the clamps c, with the expansion chamber pointing upward, and it will be in readiness for use.

To obtain a specimen of water, the dredge rope is used, having a sinker weighing 150 pounds. The apparatus being clamped to the rope a few fathoms above the sinker, lower away as rapidly as desired to the intended depth, and in case of temperature instruments not having been sent down, reel in at once.

The propellers now being brought into action soon close the valves.

The internal pressure which takes place as the apparatus ascends is relieved by the expansion chamber d. As soon as the bottle reaches the surface the valves are keyed to their seats through slots in the valve stems l. The cylinder is then removed from the frame and stowed in some cool place in a vertical position until such time as it can be delivered to the laboratory.

A vertical position is recommended in order to retain water on both sides of the piston in the expansion chamber to avoid possible drying and shrinkage of the packing.

Taking care of the bottle.—The water specimen having been procured and the cylinder removed, rinse the frame in fresh water and wipe it dry. Remove the set screws q and the shafts h, wipe them dry, and put a little oil on the screw threads.

Unscrew the sleeves i from the hubs of the propellers, wipe them dry inside and out, and oil them; wipe the propellers dry also and oil the inside of the hubs. Oil should be used sparingly, taking care that it does not drip into the cylinder.

Having cleaned and oiled the parts, put them together and stow the frame in its packing box, which should be kept in a dry place.

As soon as the specimen has been removed from the bottle the latter should be rinsed in fresh water, the valve seats unscrewed, and the cylinder with its attachments carefully cleaned and dried as directed in its preparation for use. After the parts are put together clamp the bottle in the frame. Oil should never be used on the cylinder or its attachments.

This water bottle was devised by Dr. J. H. Kidder, of the United States Fish Commission; Surgeon J. M. Flint, U. S. N., attached to the *Albatross*, and the writer. It is an elaboration of the Sigsbee water-specimen cup, carefully and strongly constructed, and, while it has successfully withstood an internal pressure of 150 pounds per square inch, there are still some mechanical imperfections to be remedied before it will be considered entirely satisfactory. It was first used on board the *Albatross* in 1884.

THE DEVELOPMENT OF DEEP-SEA EXPLORATION.

The systematic exploration of the deep sea has been confined almost entirely to the second half of the nineteenth century, and may be said to have commenced with the general introduction of steam, which not only furnished power to hoist the dredge, but brought the vessel under sufficient control for successfully working the apparatus. A sailing vessel, even under favorable conditions, was not well adapted for the work of deep-sea exploration; there were no means of preventing her drifting to leeward when hove to, and this made the preliminary operation of sounding, even in a few hundred fathoms, a difficult matter with the old-fashioned deep-sea lead line, which was slow to sink, and with its great and uncertain angle left the actual depth requisite to the successful operation of the dredge still in doubt. Hemp dredge rope, used prior to 1877, was another serious obstacle to the extension of deep-sea exploration—its size increasing with the depth, and the weights required to sink it to the bottom, in spite of the rapid drift of the vessel, increasing the load beyond the lifting capacity of appliances then found on shipboard.

Müller, one of the first recorded investigators, used a small dredge on the Danish and Norwegian coasts as early as 1779, but 30 fathoms was his greatest depth. Sir John Ross brought up specimens of animal life about 1819 with his "deep-sea clamm" from 1,000 fathoms, which caused much comment, as 300 fathoms had been generally considered the limit beyond which no life existed in the waters of the sea.

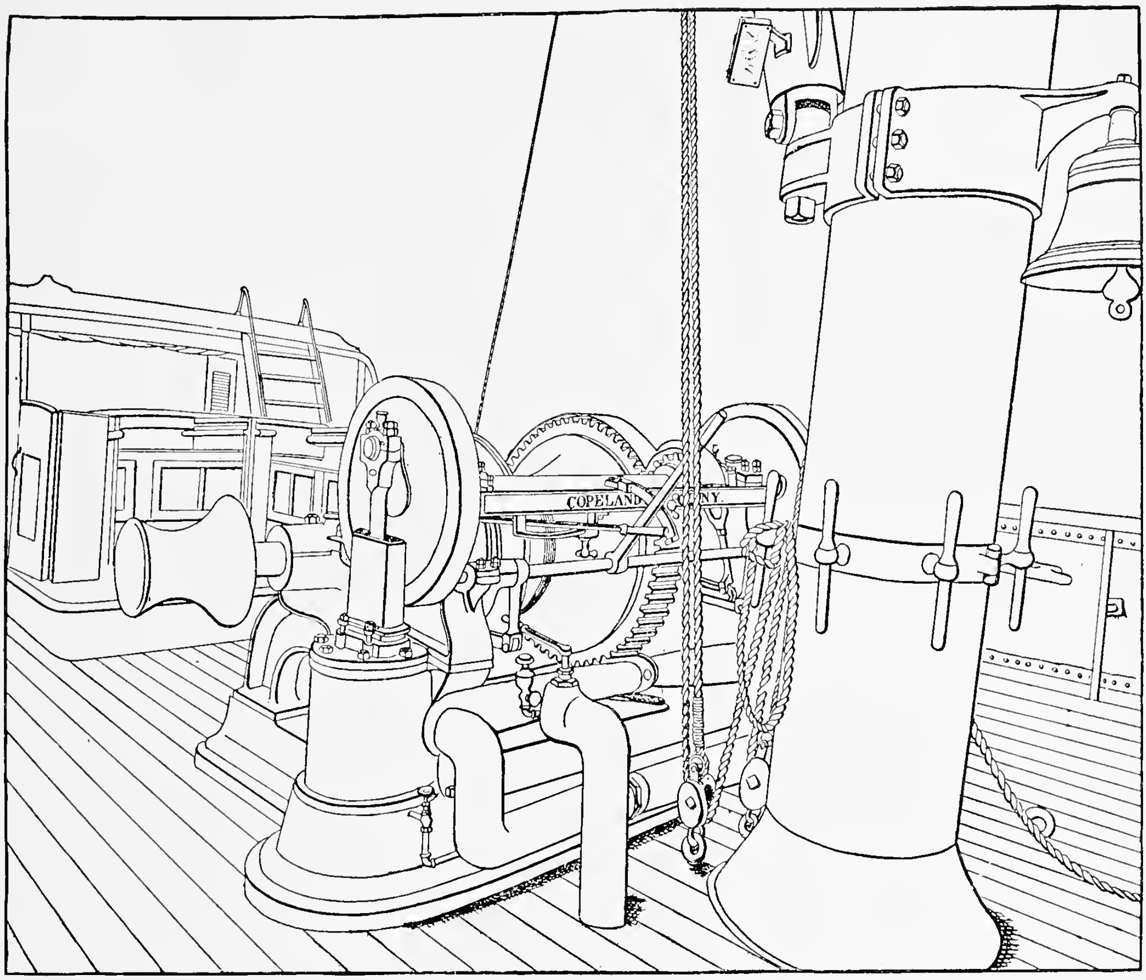
Prof. Louis Agassiz commenced his explorations of the coast waters of the United States in 1847, and Verrill and Stimpson followed in 1859, all confined to depths within 50 fathoms. In 1860 Dr. Wallich reported starfish from 1,200 fathoms, brought up on the sounding line.

From 1866 to 1869 Pourtales made an extended series of dredgings on board the Coast Survey steamer *Corwin*, Acting Master Robert Platt, U. S. N. He made a successful haul in 800 fathoms between Key West and Havana, and reached the unprecedented depth of 1,125 fathoms in the Yucatan Channel.

In 1868 Wyville Thomson and Dr. Carpenter, on board the *Lightning*, dredged in 600 fathoms between Scotland and the Faroe Islands, where they found an abundance of marine life, and, extending their explorations to 1869–70, on board the *Porcupine*, they made a successful haul of the dredge in 2,435 fathoms, which was a great triumph, considering the crude appliances of the day.

The United States Fish Commission commenced dredging operations in 1871, using hemp rope, as their predecessors had done, and, working from small vessels having limited space, with imperfect appliances of a temporary nature, they were restricted to depths not exceeding 150 fathoms.

H. B. M. S. *Challenger*, a spar-decked sloop of war of 2,000 tons and 1,200 horse-power, an unusually commodious vessel, was fitted out for deep-sea exploration and sailed on her memorable scientific cruise around the world in December, 1872. Her equipment included large quantities of hemp dredge rope which, when wet, was heavy and bulky, requiring much labor to properly attend and care for it, yet her large and

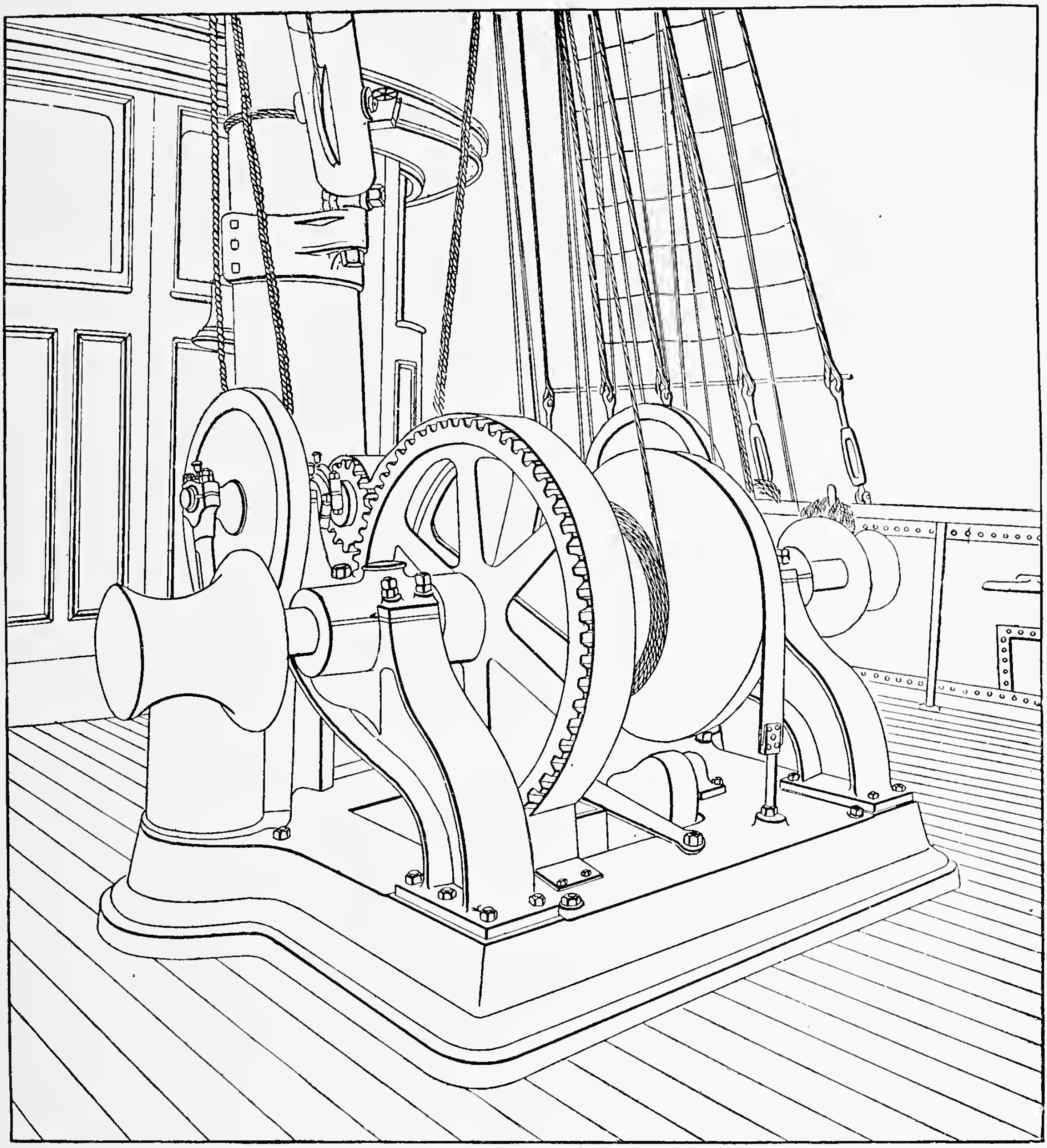


DREDGING ENGINE: AFT, LOOKING FORWARD.

Dimensions.

Greatest diameter of large gypsy head	inches	36$\frac{1}{2}$
Least diameter of large gypsy head	do	22$\frac{15}{16}$
Length of large gypsy head on line of its axis	do	24
Diameter of inboard end of small gypsy heads	do	21$\frac{1}{2}$
Diameter of outboard end of small gypsy heads	do	11$\frac{1}{2}$
Diameter of middle of small gypsy heads	do	8$\frac{1}{2}$
Length of small gypsy heads on line of their axes	do	12$\frac{1}{2}$
Total length over three gypsy heads	do	113$\frac{1}{2}$
Diameter of main shaft	do	4$\frac{1}{2}$
Diameter of spur wheel at pitch line	do	40
Pitch of teeth of gearing	do	2$\frac{1}{16}$
Width of face of gearing	do	6
Width of face of friction brake	do	4
Number of journals on main shaft		2
Diameter of journals on main shaft	inches	4
Length of journals on main shaft	do	13
Diameter of pinion on pitch line	do	9

Number of steam cylinders		2
Diameter of steam cylinders	inches	10$\frac{1}{2}$
Width of piston trunks fore and aft	do	9
Width of piston trunks athwartship	do	2$\frac{3}{4}$
Area of cross-section of each trunk	square inches	23$\frac{1}{2}$
Net area of steam pistons, each	do	74.84
Stroke of pistons	inches	10
Number of journals on crank shaft		2
Diameter of crank-shaft journals	inches	3$\frac{1}{4}$
Length of crank-shaft journals	do	6
Diameter of crank pins	do	1$\frac{7}{8}$
Length of crank pins	do	2
Length of engine base fore and aft	do	60
Width of engine base athwartship	do	96
Height of engine	do	53$\frac{1}{8}$
Weight of engine	pounds	6,500



DREDGING ENGINE: FORWARD, LOOKING AFT.

trained crew were able to handle it with alacrity, coiling it upon specially prepared pins as it was hove up or throw it off as rapidly as required for veering. The dredge and trawl were hoisted by steam power, a donkey engine being provided for the purpose. It had an ordinary gypsy head, around which several turns were taken with the rope, which was then attended by hand. The *Challenger* was the largest and best-appointed vessel ever employed in deep-sea exploration, and her subsequent achievements, including a successful haul of the beam trawl in 2,650 fathoms and a dredge haul in 3,875 fathoms, are sufficient proof of her efficiency.

The introduction of steel-wire dredge rope on board the United States Coast Survey steamer *Blake* in 1877 effected a revolution in deep-sea dredging as complete as the use of pianoforte wire accomplished in the methods of sounding.

The earlier investigations of the United States Fish Commission were conducted on board small vessels loaned by the Navy Department and temporarily equipped for deep-sea exploration. Hemp line was used for sounding, also for dredging and trawling, an ordinary engine with a single gypsy head being employed for hoisting.

A marked advance was made in the equipment of the *Fish Hawk* by the introduction of pianoforte wire for sounding and steel-wire rope for dredging.

All the later improvements bearing upon the work of the *Albatross* were embodied in her equipment, which also included many novel appliances.

DREDGING ENGINE.

Plates XXVI and XXVII represent the dredging engine, the principal use of which is to hoist the trawls and dredges, but it is provided with additional gypsy heads for hoisting boats, etc. It was built by Copeland & Bacon, of New York, according to their patents. It has three gypsy heads (the large one of steel) mounted on the same horizontal shaft, and driven by a double-cylinder half-trunk steam engine through the intervention of toothed gearing and a modification of Mason's friction clutch. The engines have locomotive valves, which are actuated by Stephenson's links and eccentries; the cranks are cast-iron disks; each pair of eccentrics is cast in one; the cut-off is effected by the lap on the valves. The machine has a friction brake to regulate the paying out of the dredge rope, and also a roller guide, with treadle motion, to press the rope aside and prevent the turns from riding. The engine is placed on the main-deck, forward of the foremast; it takes its steam from the main boilers, and may be exhausted either into the main condenser or into the atmosphere.

POWER OF THE DREDGING ENGINE.

The wire rope from the dredge passes over the dredging block at the end of the dredging boom, then under a sheave in the heel of the boom, then upward and over a block suspended from the accumulator, and then to the central (or large) gypsy head of the dredging engine.

The accumulator (plate XXXI), which is a series of rubber "buffers" moving freely on their longitudinal axes by the tension on the dredge rope, becomes a good dynamometer. By taking a large number of dynamometer readings simultaneously with indicator diagrams from the dredging engines, noting at the same time the actual velocity of the rope as it is measured by the register on the boom sheave and also the speed of the engines, and by taking the mean of these quantities we shall approach very closely to the true conditions.

The gypsy head, by which the wire rope is wound, is curved, and the rope comes in, consequently, on a varying diameter; as the mean velocity of the wire is less than that due to velocity of the center line of the wire wrapped on the smallest diameter of the head, it is evident there is a slip. The tendency of the rope, winding on the head, is to coil into a helix, but the inclination of the surface causes the wire to surge toward the central part of the head, with some jar, slipping back at the same time. The loss of power due to this slip, plus the power required to overcome the stiffness of the rope in bending it on the head, will be found by taking the difference between the net power applied to the revolution of the gypsy head and the power indicated by the dynamometer.

The diameter of the smallest part of the gypsy head is $22\frac{15}{16}$ inches, and the diameter of the wire rope is three-eighths of an inch; consequently the velocity of the rope, per revolution of the head, supposing there were no slip nor creeping, should be $\pi\left(\frac{22\frac{15}{16}+\frac{3}{8}}{12}\right)=6.104$ feet,* but from the reading of the register it is only 5.924 feet.

The following record is from the mean of a number of observations:

Velocity of the rope indicated by the register, in feet per minute	148.600
Velocity of the rope due to the smallest diameter of the gypsy head	153.100
Tension on the wire, in pounds, indicated by the dynamometer	2,737.5
Revolutions of the gypsy head per minute	25.083
Revolutions of the engine per minute	107.500
Indicated horsepower developed by the engine	15.563
Indicated horsepower required to work the engine	1.453
Horsepower absorbed by the friction of the load	1.167
Net horsepower applied to the tension on the rope	12.943
Horsepower accounted for by the dynamometer	12.327
Horsepower absorbed by slipping and bending of the rope on gypsy head	.616

The 15.563 horsepower indicated by the engine is divided as follows:

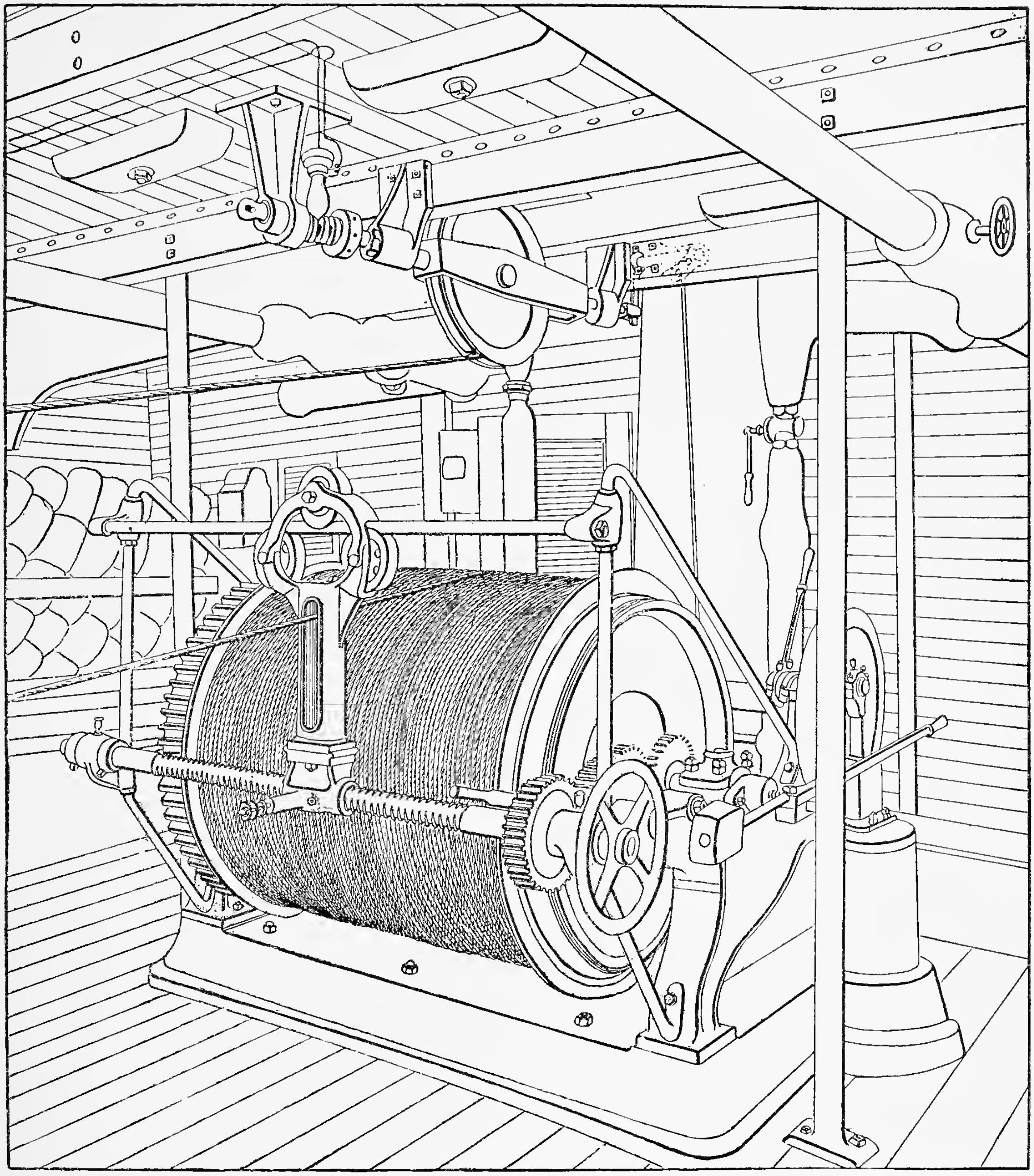
	Per cent.
For pulling in the rope	79.207
For working the engines	9.335
For overcoming the friction of the load	7.500
For overcoming the slip and bending of the rope	3.958
	100.000

REELING ENGINE.

The reeling engine was built by Copeland & Bacon, of New York, and is of the same character of design as the dredging engine. Its object is to stow the wire rope and to keep a limited tension on that rope when in motion. It is essentially a wrought-iron, built-up drum mounted on a horizontal axis driven by a double-cylinder half-trunk steam engine through the intervention of toothed gearing and a friction clutch. It has a friction brake to regulate the paying out.

It is provided with a traveling guide, mounted in front of the drum, for guiding the rope smoothly and uniformly upon it. The guide is actuated by a double screw, with equal right and left pitches, similar to that employed on the distributing roller of the Adams printing press. This screw reverses the direction of the guide when it reaches the end of the thread, and the pitch of that thread is equal to the diameter of the rope. It is geared to the drum by toothed gears of equal pitch diameters, one of which has a clutch coupling for disengaging. When paying out rope, the guide is

* This is on the assumption that the rope travels on a radius due to that of the gypsy head plus its own radius, which has been proved by the passage of the same wire over our register sheave.



REELING ENGINE AND GOVERNOR.

Principal dimensions and weight of reeling engine and wire rope.

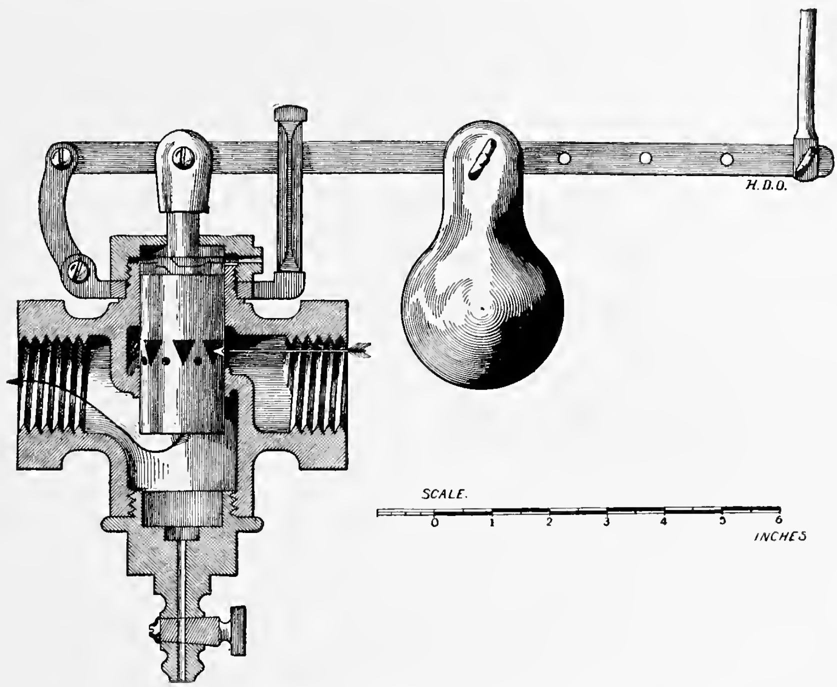
Diameter of drum	inches	16
Length of drum	do	36
Width of flanges	do	17
Ratio of gearing		$4\frac{2}{19}$:1
Number of steam cylinders		2
Diameter of steam cylinders	inches	$7\frac{1}{2}$
Stroke of pistons	do	8
Length of $\frac{3}{8}$-inch diameter wire rope reel will hold	fathoms	4,500
Weight of reeling engine	pounds	3,500
Weight of 4,500 fathoms of wire rope	do	5,940
Total weight of engine and wire rope	do	9,440

disengaged, not only from the toothed gears, but also from the double screw, which leaves it free to travel by the pressure of the wire rope upon its sides.

The engine receives steam from the main boilers and exhausts it into the main condenser or into the atmosphere, as desired.

THE GOVERNOR.

The hoisting engine being located on the main deck and the reeling engine on the deck below, entirely hidden from view, it became necessary to have some automatic device by which the movements of the former would govern those of the latter. For this purpose the governor (plate XXIX) was devised by the writer. It maintains a practically uniform tension on the dredge rope between the hoisting and reeling engines by causing the speed of the latter to conform to that of the former.



CUT 61.—Watson & McDaniel pressure-regulating valve.

The reeling engine was located on the berth deck to lower its weight in the ship and to protect it and its appurtenances from the weather.

The governor consists of the sheave *a*, within the iron frame *b*, which moves freely on horizontal axes fore and aft, allowing the sheave to revolve in any plane in conformity with the angle of the dredge rope. The forward motion of the frame *b* is checked and governed by the spring *f*, which is adjusted by the nut *e* and screwbolt *g*. On the after end of the frame *b* is a connection to an arm of a bell crank *d*, which, through the connecting rod *h*, actuates a pressure-regulating valve (cut 61) on the steam pipe between the throttle valve and reeling engine.

This valve was introduced at the suggestion of Chief Engineer Baird, U. S. N., as more effective than the original plan of attaching the bell crank directly to the throttle

valve. It acts quickly, is not liable to derangement, and is easily adjusted by pinning the connecting rod *h* through a hole in the lever, which gives the valve the desired lift.

A leading block n, 13 feet forward of the drum, may be considered a part of the governor, although detached from it. A spiral spring in its stem gives it a horizontal motion of about 6 inches, for the purpose of taking up a portion of the slack rope when it surges on the hoisting drum, thus reducing the jar and aiding in the maintenance of a uniform tension.

To adjust the governor, unwind a fathom or two of dredge rope from the reel and attach a scale to the bight, between the reel and leading block *n*; close the pressure valve and open the throttle wide; then by adjusting the nut *e*, screwbolt *g*, and connecting rod *h* admit steam to the reeling engine until the desired tension say, 300 pounds, is shown on the scale. It is advisable to verify it occasionally until the attendant becomes familiar with his duties, when he will readily make the necessary adjustment while the engines are in operation, by first shutting off steam through the pressure valve until the dredge rope is seen to slip on the hoisting drum, then gradually admitting it again until the rope is properly wound on the reel without unnecessary tension.

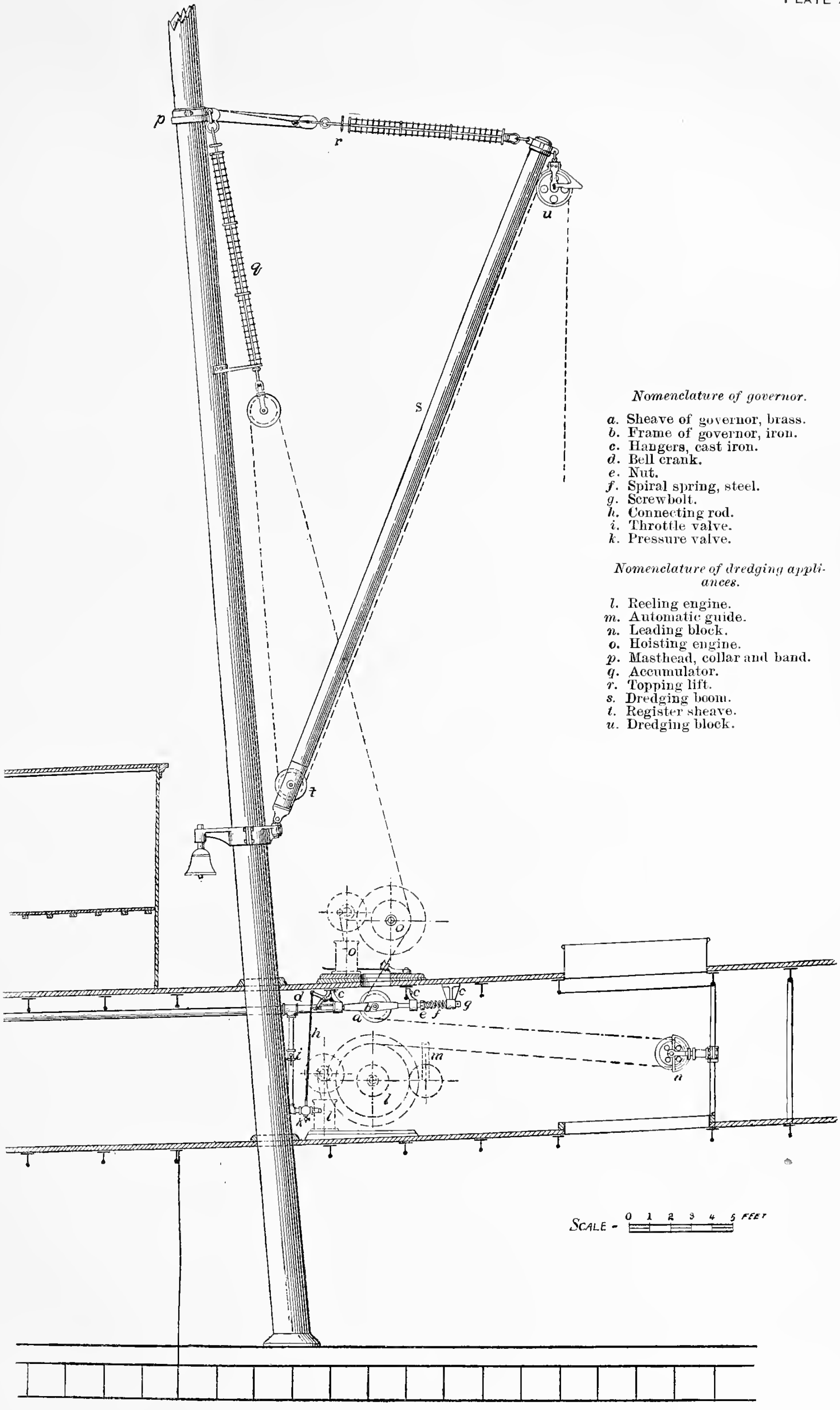
The friction clutch on the drum of the reeling engine is adjusted by a lever, so that the reel slips and ceases to turn when the prescribed limit of tension is exceeded, as happens if the pressure valve fails to act, or if the hoisting engine is suddenly reversed, in an emergency, for the immediate veering of rope.

The action of the governor is as follows: When tension is applied to the dredge rope, the pressure on the sheave *a* forces the frame *b* forward until it is arrested by the increasing compression of the spiral spring *f*; the forward movement actuating the bell crank *d* and connecting rod *h* causes the pressure valve to close and shut off steam in proportion to the movement, finally stopping the engine when the limit has been reached. The reverse movement, resulting from diminished tension on the rope, gradually admits steam through the pressure valve and starts the engine.

LEAD OF THE DREDGE ROPE.

The rope having been wound on the drum *l* of the reeling engine (plate XXIX) is first led through the automatic guide *m*, then under and over the leading block *n*, under and over the governor sheave *a*, thence to the hoisting drum *o* of the dredging engine, around which five turns are taken from forward aft and from starboard to port. The end is then carried aloft and rove, from forward aft, through the block at the lower end of the accumulator *q*, which is suspended from the mast, then under the register sheave *t* in the heel of the dredging boom, and finally over and under the dredging block *w* at the boom end.

The dredging boom s is of spruce, 36 feet in length and 10 inches in diameter. Its outer end is inclosed in a heavy brass cap and band, which has four eyebolts at equal intervals on its periphery, one each for the topping lift *r* and dredging block *u*; also one each on the forward and after sides for the boom guys. A capped sleeve of brass incases its heel. It is about 2 feet in length, mortised to receive the register pulley *t*, and enlarged on its sides to form bearings for its shaft. The heel of the boom is supported by a hinged socket bolt which passes through a hole in a heavy composition band on the foremast, upon which it pivots and turns freely and is prevented from unshipping by a nut and washer.



Nomenclature of governor.

a. Sheave of governor, brass.
b. Frame of governor, iron.
c. Hangers, cast iron.
d. Bell crank.
e. Nut.
f. Spiral spring, steel.
g. Screwbolt.
h. Connecting rod.
i. Throttle valve.
k. Pressure valve.

Nomenclature of dredging appliances.

l. Reeling engine.
m. Automatic guide.
n. Leading block.
o. Hoisting engine.
p. Masthead, collar and band.
q. Accumulator.
r. Topping lift.
s. Dredging boom.
t. Register sheave.
u. Dredging block.

LEAD OF THE DREDGE ROPE, SHOWING GOVERNOR.

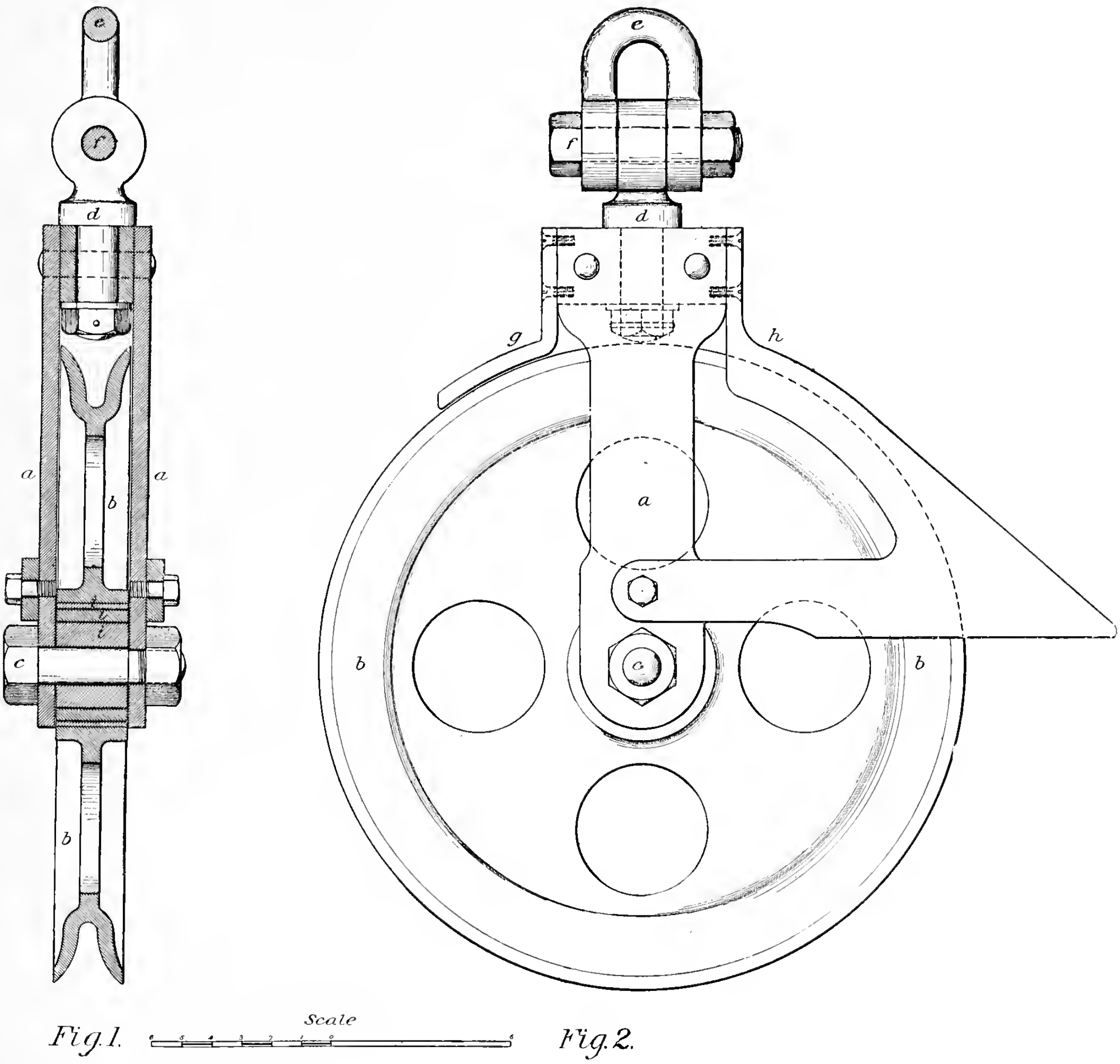


Fig. 1. Fig. 2.

DREDGING BLOCK.

Nomenclature.

a. Frame.
b. Sheave.
c. Pin.
d. Shackle bolt.
e. Shackle.
f. Shackle pin.
g. Guard.
h. Hood.
i. Bushings.

The function of the boom is to lead the dredge rope clear of the ship's side. When rigged for service, elevated at an angle of 50°, it gives a clearance of about 10 feet. When not in use, it is lowered to a horizontal position with its forward end resting upon the topgallant forecastle.

The register pulley t in the heel of the boom is of brass with a deep, narrow groove, and serves to lead the dredge rope from the accumulator *g* to the lower side of the dredging boom, besides performing its function of registering pulley. The register is attached to the left side of the sleeve at the heel of the dredging boom, is actuated by a worm wheel carried on the shaft of the register pulley, and records the number of fathoms of dredge rope out.

The boom topping lift r is a twofold purchase of 3½-inch manila rope, its hauling part shackles to a link in the masthead band *p;* the lower block is shackled to the upper end of an accumulator which, in turn, shackles to an eyebolt at the boom end. Shackles are used on the topping lift to prevent unhooking in case the dredge rope should part under heavy tension. An accumulator is attached to the topping lift to supplement the action of the main accumulator.

The boom guys, one forward and one aft, are twofold purchases of 2½-inch manila rope, heavier than required for simply holding the boom, but they are used at times in hoisting an overloaded trawl over the rail.

The boom purchase is a twofold tackle with 2½-inch manila rope used for hoisting the trawl on board; it hooks to one leg of a short pendant, the other leg carrying the after boom guy.

The dredging blocks (plate XXX) two in number, used on the lower end of the accumulator and at the outer end of the dredging boom, are leads for the dredge rope; fig. 1 is a sectional elevation, and fig. 2 a side view.

The frame *a* is composed of two pieces of bar iron 5½ inches wide at one end, 4½ at the other, 3½ in the center, and 1½ inch thick; they are secured by riveted bolts to a block of wrought iron 5½ inches in length, 2½ in width, and 2½ in depth, having through its center a 1⅜-inch hole for the shackle bolt *d*. The sheave *b* is of composition 21½ inches total diameter, 18 inches diameter at the bottom of the score, and 2¼ inches in width. It has three antifriction bushings *i i i*, the outer one of steel, fitted rigidly in place, the middle one of phosphor bronze, and the inner one of iron. The two latter move freely, and they are furnished with oil grooves on both inner and outer surfaces. The pin *c* is of cast steel, 1¼ inches in diameter. It has a shoulder at one end, which acts as a spreader for the frame and is held in place by a screw thread and nut.

The shackle bolt *d*, the shackle *e*, and the pin *f* are of the best American iron. The former is held in place by a nut and washer, which allow it to turn freely and act as a swivel. The guard *g* is of wrought iron and is intended to prevent the dredge rope from flying out of the sheave. The hood *h* acts as a guard and assists in turning the block in line with the rope so that it will lead fairly into the score of the sheave. It is a bronze casting. The nuts on the block are secured with drift pins; the guard and hood are used only on the block at the boom end.

The masthead collar and band (plate XXIX) are placed 13 inches below the futtock band on the foremast, and the accumulator and topping lift are shackled to eyes in the band. The collar is fitted in the following manner: A strong wrought-iron band, flanged on its lower edge, is secured to the mast by wood screws; the band, also of

wrought iron, is in two parts with jaws on each side, through which $1\frac{1}{4}$-inch bolts are passed and set up with nuts. When properly adjusted, there remain intervals of 2 inches between the jaws, and in these spaces, supported by the bolts, hang two links, one on each side, to which the topping lift shackles. An eye in the forward part of the band supports the accumulator, which is shackled to it.

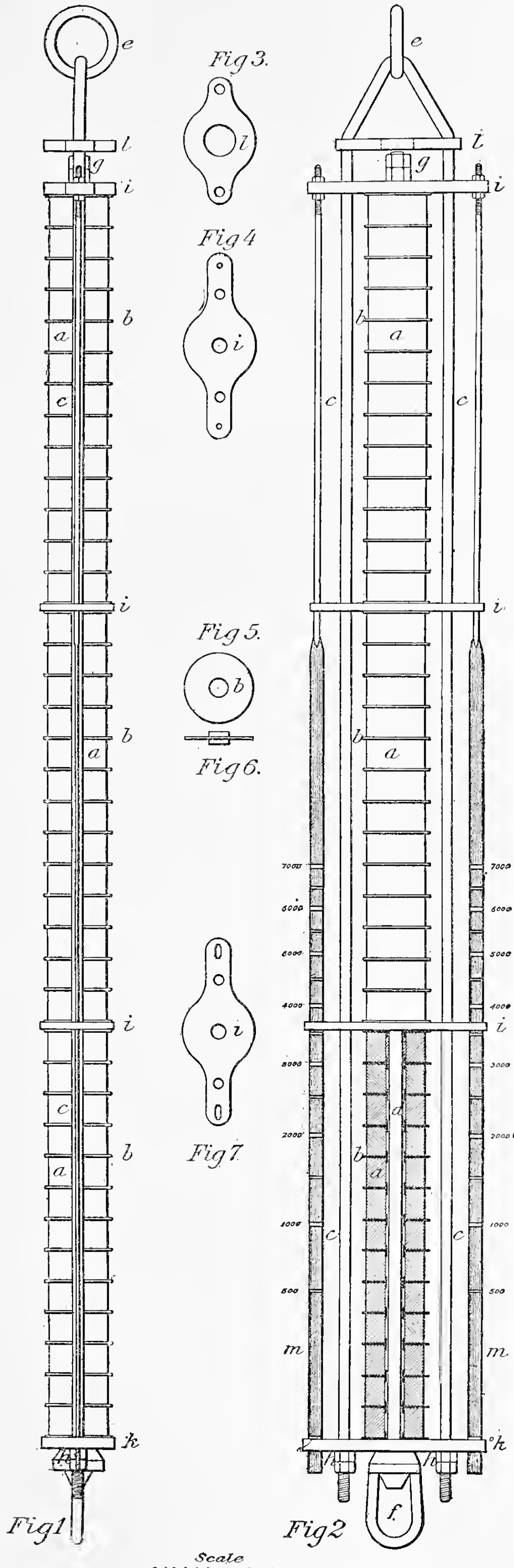
THE ACCUMULATOR.

The accumulator (plate XXXI) performs the several functions of relieving the dredge rope from jerking strains brought upon it by motion of the vessel in a seaway, insuring a more uniform action of the hoisting engine and giving the first warning of increased tension on the rope in case the trawl fouls or buries in the soft bottom when working in deep water. It also acts as a dynamometer, indicating through a graduated scale the strain to which the rope is subjected.

The guide rods c are made of a single length of round mild steel 1 inch in diameter, bent at *e* and *l*, with screw threads and lock nuts at *h*. The tension rod is of mild steel, round in section, $1\frac{1}{4}$ inches in diameter, and 9 feet 9 inches net length—that is, measured inside the crosshead *i* and yoke *k*. It holds 39 buffers without compression, and usually carries 44 in service. It has a swivel link at the lower end, to which the accumulator block shackles, and a screw thread and lock nuts *g* at the other extremity. The total length of the accumulator, including the links at each end, is 12 feet 1 inch.

The crosshead i, yoke *k*, and tie-plate *l* are of wrought iron; the former move freely on the guide rods *c*, the upper one receiving the ends of the tension rod *d* and scales *m*, while the lower ones support the guide rods and scale bars. A front view of the tie-plate *l* is shown in fig. 3, the two upper crossheads *i* in fig. 4, while fig. 7 shows the lower crosshead *i* with slots in each end through which the scales slide. The slots are made wider in the middle section to protect the painted marks on the scale bars. There is a brass washer *b* between each rubber buffer, as seen in fig. 2, where they are shown in section; they are $6\frac{3}{8}$ inches in diameter, $\frac{3}{16}$ inch thick, with a hole $1\frac{5}{16}$ inch diameter in the center. Hubs one-half inch in length extend from each side of the washers (figs. 5 and 6), except those in contact with the yoke and crossheads, which have no hub on that side. The buffers were furnished by the New York Rubber Belting Company, and are composed of their No. 23 compound; they are $5\frac{1}{2}$ inches in diameter, 3 inches thick, and have a hole $1\frac{7}{16}$ inch diameter through the center. They weigh 4 pounds 3 ounces each and cost 67 cents per pound.

The scales m are composed of two flat bars of iron, $1\frac{1}{4}$ inches wide and $\frac{1}{4}$ inch thick, attached to the sides of the accumulator, as shown in fig. 2. The upper ends are round, and carry screw threads and nuts, by which they are secured rigidly to the upper crosshead; thence they pass down through holes in the upper middle crosshead and through slots in the lower crosshead and yoke. The scale bars are graduated from the lower ends by putting gradually increasing strains on the dredge rope, rove through its blocks as for service, and to avoid accident under the higher tensions it is customary on board the *Albatross* to lay accumulator and blocks on deck or on a wharf and to use new rope; the divisions are made by painting white marks of different widths across the bars, the narrow ones representing 500 and the wide ones 1,000 pounds. The graduations once made, adjustments, incident to long service or climatic influence upon the material of the buffers, may be effected by the nuts at the upper ends of the scale bars.



Nomenclature.

a. Rubber buffers.
b. Washers.
c. Guide rods.
d. Tension rod.
e. Link.
f. Swivel link.
g. Lock nuts on tension rod.
h. Lock nuts on guide rods.
i. Cross heads.
k. Yoke.
l. Tieplate.
m. Scale.

THE ACCUMULATOR.

The action of the accumulator as a dynamometer is as follows: Tension on the dredge rope compresses the buffers, causing the scale bars to project beneath the yoke, when the degree of strain is read from the bars at their point of contact with its lower face. The marks are the same on both scale bars and on both sides of the bars, so that they can be read from forward or aft, or from either side of the deck.

The hubs on the brass washers, which prevent the buffers from coming in contact with the tension rod, were devised by Lieut. Commander Sigsbee, U. S. N., on board of the United States Coast Survey steamer *Blake*. Previous to their introduction the buffers were liable to grip the tension rod while they were compressed, making the apparatus sluggish in its action, a fault that no longer exists. It is, on the contrary, exceedingly prompt in expansion after being relieved of its load, and retains its elasticity under all conditions of service and temperature.

The illustration shows 39 buffers mounted without compression; hence the 500-pound mark on the scale is some distance above the yoke; while in actual practice, with 44 buffers under compression, it would be lowered nearly to it.

STEEL-WIRE DREDGE ROPE.

Steel-wire dredge rope was suggested by Prof. Alexander Agassiz, and first used on board the Coast Survey steamer *Blake* in 1877, when its superiority over all other material was so conclusively demonstrated that it henceforth became the standard for deep-sea exploration. The *Blake's* rope was made by the John A. Roebling's Son's Company, Trenton, N. J. It was composed of 42 galvanized steel wires, No. 19 American gauge, in 6 strands of 7 wires each, laid around a hemp heart. It was 1.125 inch in circumference, weighed 1.14 pound per fathom in air, about 1 pound in sea water, and its ultimate strength was 8,750 pounds. A kink reduced its breaking strain to 4,500 pounds.

Steel wire dredge rope was first used by the U. S. Fish Commission on board the *Fish Hawk* in 1880. It was identical with the *Blake's* rope except that it had no hemp heart.

The *Albatross's* rope of 1882 was made by the Hazard Manufacturing Company, Wilkesbarre, Pa. It was composed of 42 galvanized steel wires of the company's special gauge, approximating to No. 18 American gauge, with 6 strands of 7 wires each, and had a hemp heart. It was 1.18 inch in circumference, weighed 1.32 pound per fathom in air, about 1.2 pound in sea water, and its breaking strain was 12,850 pounds. A kink reduced its strength about 50 per cent. It was made of the best crucible steel and developed great tensile strength, but it was stiff and unpliable, kinked badly, and usually broke without warning, like tempered steel. It was used, however, until 1886, when an effort was made to procure a more pliable rope without sacrificing strength or materially increasing its size.

A quantity of English rope was procured through the agency of J. W. Mason & Co., New York, which was made of the best English mild extra plow steel, composed of 42 galvanized steel wires, No. 18½ B. W. G., approximating to No. 17 American gauge, with 6 strands of 7 wires each, around a hemp heart. It is 1.184 inch in circumference, weighs 1.31 pound per fathom in air, 1.09 pound in sea water, and its breaking strain is 14,000 pounds. It is more pliable than crucible steel rope, less

liable to kink, and consequently more durable. The loss of strength resulting from a kink is about 40 per cent.

A long splice, from 20 to 25 feet, is used to join two pieces of dredge rope, and its general features are the same as a long splice in hemp or manila, due regard being had for the difference in material. It requires close observation to detect a well-made splice, and it is as strong as any other part of the rope; at least it was found by experience on board the *Albatross* that it parted away from the splices quite as often as at them.

To turn in a thimble on the working end of the dredge rope, make an ordinary eye splice over a large oblong thimble, sticking the ends three times, tapering them as is usual with hemp or manila rope, and if a neat job is required serve the splice with annealed wire or marline.

A swivel shackle is used to attach the trawl to the dredge rope. Its utility is a mooted question, for the swivel will not work under tension, yet it turns freely the moment the strain is removed from the rope after a long or heavy lift, and this relief may be of service in lessening the liability to kink while lowering the trawl for a subsequent cast.

The preservation of galvanized steel-wire dredge rope from rust is of little moment while it is new, but as the zinc wears off and the steel is exposed its life may be materially lengthened by the systematic application of a suitable preservative. It rarely happens in service that more than one-half of the rope is paid out, and when it is reeled in it is always wet with salt water, which percolates from layer to layer through the rope remaining on the reel, keeping it constantly wet during the working season. It is to the action of sea water thus confined that we trace one of the main causes of oxidation.

It has been the custom on board the *Albatross* to run the rope off from its reel twice a year, winding it directly upon the steam capstan, which is furnished with suitable wooden heads for the purpose. It is carefully wiped as it leaves the reel, the splices and nips or partial kinks are examined, and the necessary repairs made; and a clear day having been selected for the transfer, the rope reaches the capstan quite dry.

The service reel having been examined and painted, the rope is replaced upon it, and during its transit it is again wiped and given a coat of linseed oil, as many men as can work to advantage being stationed between the capstan and reeling engine for this purpose; oil is freely distributed over the rope after it has reached the reel, and by constant dripping from layer to layer during the process of winding it penetrates the interstices of wires and strands, and by the time the rope is all upon the reel it has become thoroughly coated.

The fluidity of the oil may be greatly increased, and its application facilitated by warming it; this may be done by keeping it in a bucket of hot water while it is being applied.

Spare rope on wooden reels requires no attention, providing the storeroom is dry and secure against occasional leakage; otherwise it will be well to see that the reel heads are tight and give the surface of the rope two or three coats of lead-colored paint.

The proper lengths in which dredge rope should be ordered will be governed by circumstances. It can be procured from the manufacturers in any desired length, delivered on wooden reels in convenient form for transfer to the service reel, or for storage. If large storerooms are available and facilities are at hand for handling

heavy weights, or if it is practicable to carry the reel mounted upon an axle in readiness for running off wire without changing its position, a single length of 5,000 fathoms would seem to be best for the spare rope.

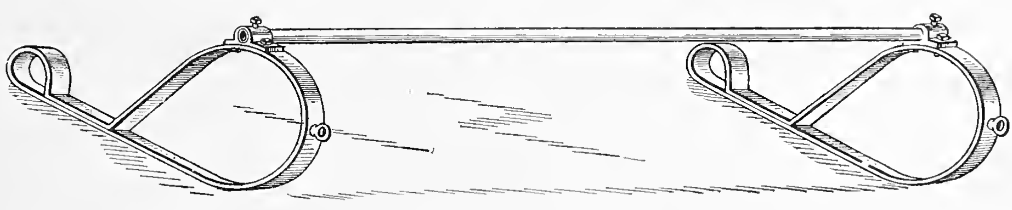
If the working reel is empty and is to be filled, a sufficient quantity should be ordered in one length. On board vessels of ordinary capacity, carrying, as the *Albatross* usually does, 4,000 fathoms of spare rope, there should be one reel containing a single length of 2,000 fathoms, one of 1,000 fathoms, and two with 500 fathoms each. The same wooden axle will answer for all of the reels.

The transfer of dredge rope from a wooden transporting reel to the service reel is a simple operation, providing the former is firmly secured in place and a strong uniform tension is maintained upon the rope. The transporting reel may be placed on deck, in the hold or storeroom or on a wharf, and the rope led through ordinary blocks to the dredging-boom end; thence to the service reel it should be led through its regular channels. The reading of the register should be noted in order that the exact amount of rope upon the reel may be known; in fact, it is good practice, strictly followed on board the *Albatross*, to note the register whenever rope is wound upon or veered from the service reel, either in large or small quantities, entering expenditures or losses from any cause in the record book, also noting the amount remaining in its appropriate place in the correction table; otherwise errors are sure to creep into the applied corrections.

BEAM-TRAWL FRAME.

The beam-trawl frame shown in cut 62 was in general use on board the *Albatross* during the first year of her cruise for both shoal and deep water work, and while it was satisfactory under ordinary conditions it was not considered the best form under all circumstances. Its dimensions are as follows:

Beam: Iron pipe; length, 11 feet; diameter, outside, $2\frac{7}{8}$ inches; thickness of metal, $\frac{3}{16}$ inch.
Collars: Cast brass; length of flange, $9\frac{1}{2}$ inches; width, 4 inches; thickness of metal, $\frac{3}{4}$ inch.
Bolts: Iron; length, $2\frac{1}{2}$ inches; diameter, $\frac{3}{4}$ inch.
Runners: Flat bar iron, 4 inches wide, $\frac{3}{4}$ inch thick; length, 5 feet; height, 2 feet 5 inches + 4 inches for the beam; total, 2 feet 9 inches.
Weight of frame, 365 pounds.



CUT 62.—Beam-trawl frame.

The several parts are interchangeable; the net with its appendages is identically the same as that used with the Tanner beam trawl No. 1 and will be described in connection with it.

THE TANNER BEAM-TRAWL FRAME.

The trawl frame shown in cut 63 is a modification of the form just described. The beam and collars remain the same and are interchangeable; the runners are the same length and height but their form is different, both top and bottom being made

the same shape, thus doing away with all sharp angles and equalizing the strain over the various parts of the head of the net, besides carrying it higher in rear of the beam, giving the mouth a wider opening and greatly increasing its strength and efficiency. It is better balanced also and less liable to capsize in lowering or to catch on foul bottom; it is more simple in construction, and lighter by about 100 pounds, which is an advantage in handling it in a seaway. The jackstays and guard nets sometimes attached to the inner surfaces of the runners are useful in shoal water and in moderate depths, where swift-moving forms are mostly encountered.

The frame is composed of an iron beam having a brass collar screwed on each end and held rigidly in place by set screws. Each collar has two holes, through which square-headed bolts, with nuts, are passed for the purpose of securing it to its runner, the bolts being habitually carried in their respective holes ready for use.

Cut 63.—Tanner beam-trawl frame.

Eyebolts, to which the bridles are seized, are secured to the forward ends of the runners by nuts. Beams and runners are interchangeable.

THE TANNER BEAM TRAWL No. 1.

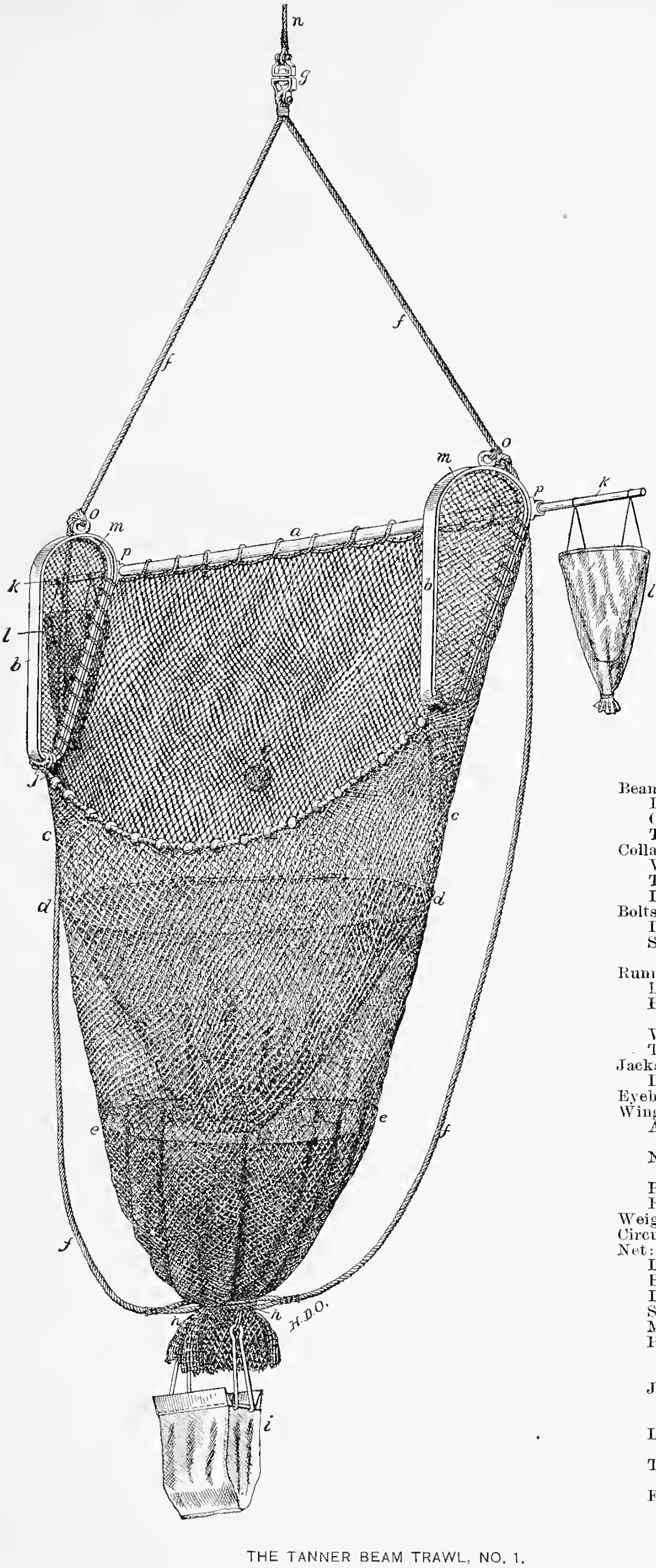
The trawl is here represented completely mounted (plate XXXII), ready for service, showing the method of attaching trawl net, bridles, wing nets, and mud bag, and, as it has become the standard on board the *Albatross* for general work, it will be described in detail.

To assemble the Tanner beam trawl, place the runners *b* and beam *a* in position, pass the bolts through holes in the collars *p* and runners *b*, and set the nuts tight with a wrench; place the head cringles or eyes of the trawl net over the heads of the beam set screws, middle a piece of 9-thread manila, and, commencing with the bight at the center of the beam, lace both ways to the beam ends, thence down the backs of the runners, securing the apron in the same manner, and, if there is end to spare, wrap it around the rear bends above the lead-rope hitches. Bend the free ends of the lead rope to the rear extremities of the runners, as low down as practicable, with a clove hitch, taking jamming turns above, if necessary, to prevent its slipping up; if there are spare ends, stop them along the back of the runners. Adjust the drawstring at the bottom of the pocket *d*, seize the bridle stops *o*, gather in the tail of the net and the bridle legs, pass the lashing *h*, and hitch the mud bag *i* to the eyes of the bridle legs.

The wing nets *l* are kept slung to the arms *k*, and to attach them to the trawl loosen the beam set-screws and slip them into the ends of the beam about 6 inches and hold them in place by again tightening the set-screw. Trawl weights are used to facilitate the sinking of the net, and ordinarily a single weight of 28 pounds is attached to each runner by a long tail rope, and one to the end of the net by a short

Nomenclature.

a. Beam, iron pipe.
b. Runners.
c. Trawl net.
d. Pocket.
e. Jacket.
f. Bridle.
g. Swivel shackle.
h. Lashings.
i. Mud bag.
j. Lead rope.
k. Arms, wood.
l. Wing nets.
m. Guard nets.
n. Dredge rope.
o. Bridle stops.
p. Collars, brass.
q. Float glass.



Dimensions.

Beam (iron pipe):
 Length, 11 feet.
 Outside diameter, $2\frac{7}{8}$ inches.
 Thickness of metal, $\frac{3}{16}$ inch.
Collars (brass):
 Width, $3\frac{1}{2}$ inches.
 Thickness, $\frac{3}{4}$ inch.
 Length, $9\frac{1}{2}$ inches.
Bolts (iron, round):
 Diameter, $\frac{3}{4}$ inch.
 Set screws, in collars, iron, square heads, diameter, $\frac{3}{4}$ inch.
Runners (iron, flat-bar):
 Length, 5 feet.
 Height, 2 feet 5 inches; including collars, 2 feet 9 inches.
 Width, $3\frac{1}{2}$ inches.
 Thickness of metal, $\frac{1}{2}$ inch.
Jackstays (iron, round):
 Diameter, $\frac{1}{4}$ inch.
Eyebolts (brass): Diameter of metal, $\frac{3}{8}$ inch.
Wing nets:
 Arms, wood; length, 2 feet 6 inches; diameter, $2\frac{1}{2}$ inches.
 Nets, material, cheese-cloth; length, 3 feet.
 Pocket, length 2 feet.
 Ring, diameter 1 foot.
Weight of frame, 275 pounds.
Circumference of bridle rope, 3 inches.
Net:
 Lead rope, circumference, 2 inches.
 Head rope, circumference, $1\frac{1}{2}$ inches.
 Length, 17 feet.
 Size of mesh, square, 1 inch.
 Material, cotton, barked, 30-thread.
 Pocket, length, 6 feet; size of mesh, square, 1 inch; material, cotton, barked, 21-thread.
 Jacket, length, 6 feet; size of mesh, square, $\frac{1}{2}$ inch; material, cotton, barked, 16-thread.
 Lining, material, cheese-cloth; length 3 feet.
 Tail lashing, 15-thread manila, length 3 fathoms.
 Float, Norwegian glass globe, diameter 6 inches.

THE TANNER BEAM TRAWL, NO. 1.

one. The long tails are used on the runners in order that they may be released from their weight as soon as the trawl frame reaches bottom, where its tendency is to sink into the mud or ooze, and the short lashing at the end of the net is to prevent the weight from interfering with the mud bag. The float *q* is seized to the back of the net a little forward of the lead rope, and its purpose is to enlarge its entrance.

The bridle is of 3-inch manila rope, 14 fathoms in length, and is fitted by turning a thimble into the bight, taking an overhand knot in both legs about 8 feet from the thimble, and splicing eyes in the ends, longer or shorter, as required to make the legs hang a little slack when the net is loaded.

The bridle stops are of marline; they are used to seize the bridle legs to the eyebolts in the forward end of the runners; the number of turns is determined by experiment, the intention being that they shall break before a dangerous strain is put upon the dredge rope. A Duckham weighing machine is used on board the *Albatross* for determining the strength of the stops, and with the ordinary quality of marline nine turns break with a load of 5,000 to 6,000 pounds, the limit allowed with new rope.

The bridle and bridle stops are practically the same for all of the trawls described except the Tanner No. 3, the only difference being in the length of the legs; those for the beam trawl and the Tanner No. 1 are the same; the Blake trawl requires them about 3 feet longer, and the Tanner No. 2 as much shorter.

Trawl weights are attached to frame and net in sufficient numbers to insure the prompt sinking of the trawl. They are square in cross section, 11 inches in length, 4 inches in diameter at the base, and 3 at the upper end, which is flattened and pierced with a hole for the tail. Manila rope, 15-thread, and 1 fathom in length, is used for the purpose. The apparently awkward shape was adopted to prevent the weights from rolling about the decks in heavy weather. They will stand upright ordinarily, and will not roll under any circumstances. They weigh from 28 to 30 pounds.

Tail lashings for trawl nets are of 15-thread manila rope, about 3 fathoms in length. Soft, pliable rope is preferred.

Floats for trawl nets were formerly made of cork, which answered the purpose in moderate depths, but became water-logged and worthless under the pressures encountered in deep-sea work; hence Norwegian glass floats were introduced. They are spherical in form, 6 to 7 inches in diameter, thickness of glass $\frac{1}{4}$ to $\frac{3}{8}$ inch, and they are inclosed within hand-made netting, having small eyes worked on opposite sides, through which their lashings are secured. Floats are attached to the upper part of the trawl net in rear of the beam, and it is their function to keep it elevated as much as possible, thus increasing the area of the opening or mouth. They have, with few exceptions, withstood the pressure even in depths approaching 3,000 fathoms, and they are seldom broken, owing to their secure position on the trawl net and the protection given them by their covering of netting.

Wing nets were introduced by Capt. H. C. Chester and first used on board the *Fish Hawk* in 1880. Nets of various forms have been used for intermediate collecting, but they were attached to the dredge rope. The present form is a modification of the Chester net, and was devised by the writer in 1884, since when they have been in constant use on board the *Albatross*. They are made of cheese-cloth in the following manner: The material is laid on deck and folded once, a pattern placed upon it, and the two halves cut from the piece at the same time; the side seams are then sewed up, the ends hemmed, and one extremity turned inward over a galvanized iron ring,

thus forming the pocket. The double bridle is seized to the ring through the net and serves to hold it in place. The tail lashing is sewed to the end of the net to prevent its being lost when cast adrift. There is a drawstring in the end of the pocket and a cord, with a knot in its lower end, is secured to the pocket and allowed to hang down far enough to be gathered in with the end of the net, and secured with the lashing to prevent its turning inside out when the trawl first takes the water. The arms are of wood, with deep scores for the reception of the bridles.

The mud bag is simply a boat dredge minus its net; the lower end of its canvas shield is closed for the purpose of bringing up an unwashed specimen of bottom soil. A detailed description will be found under the title of "boat dredge."

THE TANNER BEAM TRAWL NO. 2.

This trawl is a duplicate of No. 1, except that it is smaller and lighter, being especially designed for use in heavy weather when No. 1 can not be safely operated, or on doubtful or foul ground where the apparatus is liable to be sacrificed. It is much used also for rapid towing in shallow water in the examination of fishing banks.

Its dimensions are as follows:

Beam: Iron pipe, length, 7 feet 6 inches; outside diameter, $2\frac{1}{4}$ inches; thickness of metal, $\frac{3}{16}$ inch.
Collars, brass; width, 2 inches; thickness, $\frac{1}{2}$ inch; length of flanges, 7 inches; diameter of bolts, $\frac{5}{8}$ inch.
Runners: Length, 4 feet; height, 2 feet 3 inches + 3 inches for height of beam; total, 2 feet 6 inches; width, 2 inches; thickness of metal, $\frac{5}{8}$ inch.
Weight of trawl frame, 140 pounds.
Rope for bridle, $2\frac{1}{2}$ inches; manila.
Rope for lead rope, 2 inches; manila.
Rope for head rope, $1\frac{1}{2}$ inches; manila.
Trawl net: Length, 17 feet; size of mesh, square, 1 inch; material, cotton, barked, 30-thread; pocket, length, 6 feet; pocket, size of mesh, square, 1 inch; pocket material, cotton, barked, 21-thread; jacket, length, 6 feet; jacket, size of mesh, square, $\frac{1}{2}$ inch; jacket material, cotton, barked, 16-thread.
Float: Norwegian glass globe, diameter, 6 inches.

THE TANNER BEAM TRAWL NO. 3.

This handy little trawl has the same general form as Nos. 1 and 2, and is especially designed for boat service. It was first used in March, 1894, for the scientific exploration of San Diego Bay, California, when it was so highly appreciated that it was at once adopted as a part of the dredging outfit of the vessel. Its dimensions are as follows:

Beam: Iron pipe, length, 3 feet 6 inches; diameter outside, $1\frac{1}{4}$ inch.
Bolts: Iron, square; diameter, $\frac{1}{2}$ inch.
Runners: Iron, flat bar, $1\frac{1}{2}$ by $\frac{1}{4}$ inch; length, 2 feet 7 inches; height, 1 foot 1 inch.
Weight of frame, 16 pounds.
Net: Material, cotton, barked, 21-thread; size of mesh, 1 inch square; length of net, 7 feet; jacket material, cotton; thread, 24–6 stow, barked; size of mesh of jacket, $\frac{1}{4}$ inch square; length of jacket, 2 feet 6 inches.
Rope: Head, leech, lead ropes, and bridle, 9-thread manila; tow rope 15-thread manila.

The several parts of the frame are secured by close-fitting square bolts through holes in the runners and flattened ends of the beam, set up with nuts. The legs of the bridle are secured to the runners with light seizings, and the ends extended to the tail lashing, as in Nos. 1 and 2, for the purpose of recovering the net tail first, in case the trawl is caught on the bottom and the bridle stops part.

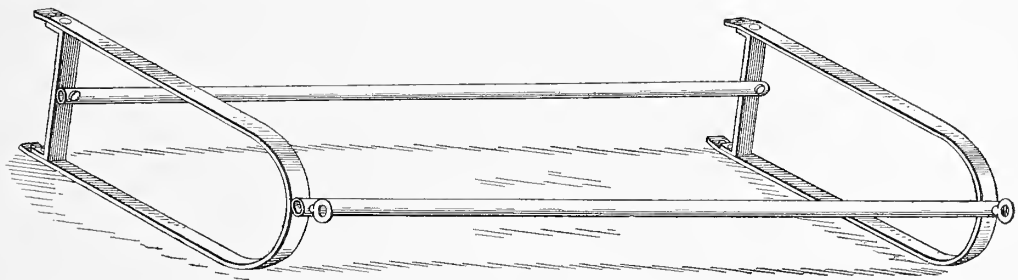
A float of cork is used upon the top of the net to extend its mouth. The pocket is omitted to save weight.

THE BLAKE DEEP-SEA TRAWL.

The Blake Trawl (cut 64) is designed for deep-sea work, as its name implies, and is not well adapted for use on the hard, sandy bottom usually encountered in shoal water, owing to the limited height of the beam and restricted sweep of the lead rope. It is practically a double beam trawl with central beams, and lead ropes on both sides, so that it is a matter of indifference how it lands.

This is a great advantage which all deep-sea explorers will appreciate after operating the beam trawl, the successful use of which depends upon its being landed on the bottom right side up, a feat which the expert will accomplish with rare exceptions, even in the greatest depths; but the inexperienced explorer will frequently discover, to his chagrin, that it has been dragging bottom side up and the haul is a practical failure in consequence. The Blake trawl admits of a change of course in any direction and to any extent while it is dragging on the bottom, providing the dredge rope is not slackened sufficiently to allow it to kink.

The disadvantage in the use of this trawl is the greater wash through its widely distended mouth during the ascent, which is injurious to the more delicate forms, but



CUT 64.—Blake deep-sea trawl frame.

this evil is largely compensated by the cheese-cloth lining and the protecting folds of the net. Its dimensions are as follows:

Beams, front and rear: Material, iron pipe; length, 10 feet; diameter outside, 2¼ inches; thickness of metal, 3/16 inch; holes in ends, ¾ inch square.

Runners: Material, flat bar iron; width, 3 inches; thickness, ½ inch; length, 4 feet 6 inches; height, 2 feet; holes for beams, ¾ inch square; holes for lead rope, 1 inch diameter.

Bolts: Material, iron; size, ¾ inch square, with thread and nut; length, 3½ inches; rear with flat heads; front with eyes for bridle.

Weight of frame, 200 pounds.

Net; Material, cotton, barked, 30-thread; size of mesh, square, 1½ inch; length, 20 feet.

Pocket: Material, cotton, barked, 21-thread; size of mesh, square, 1 inch; length, 6 feet.

Jacket: Material, cotton, barked, 16-thread; size of mesh, square, ½ inch; length, 6 feet; lining, cheese-cloth.

Rope, manila; lead and leech ropes; circumference, 2 inches; bridle, 3 inches.

Float, Norwegian glass globe; diameter, 6 inches.

The space between the front and rear beams, and sometimes the inner surfaces of the runners, are filled with netting tightly laced from side to side to increase the lead into the mouth of the net; the former is of undoubted utility, as the upper lead rope sags nearly to the level of the rear beam, thus reducing the area of the opening nearly one-half.

To assemble the Blake deep-sea trawl, place the runners in position and secure the beams to them with the bolts which are habitually kept in the holes in the beam ends; those for the front one have heads terminating in eyes for the bridle, otherwise the beams are interchangeable. Attach the net by seizing the lead ropes through holes in the runners, leaving them with slack enough to sag to the beam; lace the leeches to the rear ends of the runners, and adjust the drawstring in the lower end of the pocket, leaving an opening about 2 feet in diameter.

Seize the bridle to the eyebolts on the runners, using from six to eight turns of marline; gather in the end of the jacket, the cheese-cloth lining, trawl net, and the bridle legs, and pass the tail lashing. Hitch the mud bag to the eyes in the bridle legs, and attach as many trawl weights as required to frame and net, the number being determined by the depth of water, nature of the bottom, strength of current, and the state of the sea.

This trawl is the joint production of Commander C. D. Sigsbee, Professor Agassiz, and officers of the *Blake*, on which vessel it was brought into successful operation.

MATERIAL FOR TRAWL NETS.

The webs from which nets are made for the beam trawl and the Tanner trawls, Nos. 1 and 2, are of three sizes, all barked. For body of net, 30 thread, 1-inch mesh, square, hanging 17 feet or 150 meshes deep; for pocket, 21 thread, 1-inch mesh, square, hanging 6 feet or 54 meshes deep; for jacket, 16 thread, ½-inch mesh, square, hanging 6 feet or 108 meshes deep. For the Blake deep-sea trawl a larger mesh is used, though the web remains the same in all other respects. It is 30-thread, 1½-inch mesh, square, hanging 17 feet or 100 meshes deep. The material for pockets and jackets is the same as that described for beam trawl nets.

Material for the Tanner beam trawl net No. 3 is 21-thread, 1-inch mesh, square, and for the jacket, thread 24–6 stow, ¼-inch mesh, square.

The hang of a web is its natural form, with the meshes square, occupying the same space in length and width. Square measure is the length of one side of the mesh, and stretch measure is the total length of mesh when extended; hence the latter is double the former. Stretch measure is in general use among net-makers.

Lead rope sinkers for trawl nets are oval in form, the larger size about 2 inches in length, 1½ inches in diameter, and a ¾-inch hole through the center, while those for the Tanner No. 3 net are 1½ inch in length, ¾ inch in diameter, and a ⅜-inch hole.

DIRECTIONS FOR MAKING TRAWL NETS.

BEAM TRAWL AND TANNER TRAWL NO. 1.

To make a net for the beam trawl or for the Tanner trawl No. 1, cut from the web 50 feet, stretch measure, or 300 meshes; take 4 fathoms of 1½-inch manila rope, whip both ends, and middle it, also find the middle of one end of the web and hitch it to the headrope with a netting needle, working both ways from the center; make a small eye in the headrope at each corner of the net, to serve as head cringles; then continue down the sides of the apron, stitching them to the same rope for a space of 4 feet 6 inches, taking up 45 meshes. There are 50 meshes in the apron, but the remaining 5 are left unroped for a purpose that will presently appear. The length of leech ropes,

although given as 4 feet 6 inches, is intended to reach the lead rope at its hitches on the rear of the runners.

To prepare the other end of the web for the lead rope, cut a sweep of 30 meshes from it; whip the ends of a piece of 2-inch manila rope, $3\frac{1}{2}$ fathoms in length, for the lead rope; slip 18 or 22 sinkers on it, as it is intended for deep or shoal-water work; middle it, and measure off 7 feet each way, marking the points permanently, thus indicating the length of the lead rope, 14 feet. Commencing at the middle of rope and web, hitch them together with a netting needle as before, distributing the sinkers evenly along the former, then splice the leech ropes to it, commencing at the marks and sticking the strands outward.

The leech ropes should be spliced at the 4 feet 6 inches mark, thus leaving the 5 unroped meshes in a bight between the leech ropes and the lead rope, for without this precaution the net will invariably give way at that point first. Now bend the net temporarily to its frame and hoist it up until the web swings clear of the deck; then let a man get into the bight of the web and move back and forth until he has found the lowest point; cut it and stitch the sides together, beginning at the junction of leech and lead ropes, working toward the tail of the net. This done, turn it inside out and stitch the pocket on 12 feet and the jacket 6 feet from the lower end, or so that the bottom of the latter and the tail of the net will hang evenly. Run a drawstring through the lower meshes of the pocket, and seize the float to the back of the net above and a little forward of the lead rope.

A cheese-cloth lining is sometimes stitched to the jacket for deep-sea work, but it is of doubtful utility, as the net usually brings up sufficient bottom soil to protect delicate forms during the ascent of the trawl. If used, it should hang evenly with the jacket and tail of the net, and extend not more than 2 feet above the lashing. When completed the net may be unbent and stowed away until required for use.

Trawl nets have been kept in canvas bags, but the practice is not recommended. They keep better in a bundle, tied as loosely as circumstances will admit.

NET FOR THE TANNER TRAWL NO. 2.

The No. 2 nets are usually made in pairs in order to economize material, which is the same in all respects as that used in the larger nets. Cut from the web a piece containing 108 meshes, or 18 feet stretch measure, and another with 73 meshes, or 12 feet stretch measure; cut both in half lengthwise and use one long and one short piece for each net.

Take 17 feet of $1\frac{1}{2}$-inch manila rope, whip both ends and middle it, also middle an end of the longest web and hitch it to the rope with a netting needle, working each way from the center; make a small eye in the head rope at each corner of the net to serve as head cringles; then continue the roping down the sides of the apron 3 feet 6 inches, or sufficient length to reach from beam to lead rope without strain, taking up 32 of the 35 meshes, the remaining 3 being left unroped.

Cut a sweep of 21 meshes from one end of the shorter web, take 14 feet of 2-inch manila rope, whip the ends, middle it, measure 4 feet 9 inches each way, and mark the points to indicate the length of the lead rope, 9 feet 6 inches; slip on 15 sinkers and distribute them equally; then stitch the rope to the web, and splice the leech ropes to the lead rope. The marks on both should be brought together, leaving the 3 unroped meshes in a bight between them.

Bend the net to its frame, trice it up, and stitch the sides together, turn it inside out and attach the pocket 9 feet and the jacket 3 feet from the lower end of the net. The materials for pocket and jacket are the same as in the larger nets, but the latter is only half the width, the other half being used for the second net of the pair. Run a drawstring through the lower meshes of the pocket and seize the float to the top of the net over the lead rope.

NET FOR THE TANNER TRAWL NO. 3.

The body of the net is made from the web used for pockets in the larger nets, 21-thread, 1-inch mesh, square, hanging 54 meshes or 6 feet deep. Two pieces of 40 meshes each are cut from the web, and using 9-thread manila the head and apron are roped, the latter containing 20 meshes on leech ropes 26 inches in length. For the lead rope take 7 feet of 9-thread manila, whip the ends, middle it, measure 2 feet 3 inches each way, and mark the points to indicate its length, 4 feet 6 inches; cut a sweep of 10 meshes from one end of the second piece, stitch it to the lead rope, first slipping on 8 sinkers weighing about $\frac{1}{4}$ pound each, and distributing them evenly along its length. Splice the leech ropes into the lead rope, stitch the sides of the net, and square the lower end.

The jacket, 2 feet 6 inches in depth, composed of 24–6 thread stow, $\frac{1}{4}$-inch mesh, square, is next stitched on, and the float seized in place, the pocket being omitted to save weight.

THE BLAKE DEEP-SEA TRAWL NET.

From the web, which is 30-thread cotton, $1\frac{1}{2}$-inch mesh, square, hanging 17 feet or 100 meshes deep, cut 172 meshes, or 43 feet stretch measure; take about 31 feet of 2-inch manila rope, slip 13 sinkers on one end, then make three small eyes along its length, the first 4 feet from the end, the second 10 feet 8 inches in the clear from the first, and the third 2 feet from the second. Slip 13 sinkers over the other end of the rope and make a fourth eye 10 feet 8 inches from the third; connect the ends with a long splice, leaving 2 feet between the fourth and first eyes, thus forming the two lead ropes 10 feet 8 inches, and two leech ropes 2 feet in length. The web, which is in one piece, is prepared for roping by cutting a sweep of 6 meshes from the first 70; then, with an interval of 18 meshes, cut another sweep of 6 meshes within the next 70, and, with a netting needle, hitch the first sweep to the first lead rope, taking up 70 meshes, then 18 meshes as a leech; 70 on the second lead rope, and 18 on the second leech. Commencing at the lead rope, lace the ends of the web together, then turn the web inside out and attach the pocket and jacket, the former 12 feet and the latter 6 feet from the tail of the trawl net.

Should a cheese-cloth lining be added, stitch it to the jacket so that it will not extend more than 18 inches or at most 2 feet above the tail lashing.

The float is seized to the bight of a bridle the ends of which are lashed to the sides of the net, between the upper and lower parts, in such a manner that it will hang near the lead ropes, but can not float outside of them. Run a drawstring through the lower meshes of the pocket.

GENERAL REMARKS.

The meshes are spaced wider on the lead ropes than on the leeches or ends, and they should be spaced closer near the corners than in the middle sections, in order to equalize the strain on different parts of the net.

In selecting material for lead ropes, particularly for the Blake deep-sea trawl net, better results will follow by using rope that has been a short time in service, as a taekle fall for instance, until the extra turns are taken out of it and it has become pliable and well set. Condemned running rigging has been used, but it is not recommended, owing to its uncertain strength. The praetiee of bending trawl nets to their frames as soon as they are roped and tricing them up while the side seams are being laeed and pockets and jackets attached is recommended, as the finished net invariably sets better when so treated.

A trawl net should set very loosely on its frame when dry, for if it fits snugly then its shrinkage when wet will be sufficient in most cases to impair its usefulness.

The net length is given for head, leeeh, and lead ropes, no allowance being made for shrinkage by wetting, as that depends largely upon the rope used.

THE DREDGE.

The dredge in ordinary use on shipboard is shown in eut 65. It is composed of a pair of beveled jaws flaring about 12 degrees and joined together by an iron stud at each end, which is welded to the jaws. The net is laced through holes along the back edges of the jaws, and protected from chafing on the bottom by a canvas shield whieh is drawn over it and laced through the same holes.

Iron arms serve as a bridle. One arm is a little shorter than the other and is secured to the larger one by a seizing which is intended to part whenever undue strain is brought upon it, allowing the dredge to be drawn up by one arm, in which position it would be most likely to free itself from an obstruetion. Its dimensions are as follows:

Jaws: Length, 2 fect; width, 2½ inches; opening betwcen, 8 inches; angle of 12 degrees.

Stud: Length, 6 inches; diameter, round iron, ¾ inch.

Bridle: Diameter, round iron, ¾ inch; weight of metal part, 26 pounds.

Net: Length, 3 feet 6 inches; size of mesh, square, 1 inch; material, cotton, barked, 30-thread; jacket, length, 2 feet 6 inches; jacket, size of mesh, ½ inch; jacket material, cotton, barked, 16-thread; bottom lining, cheese-cloth.

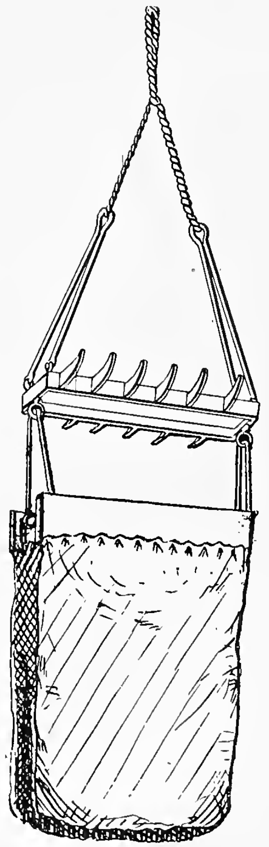
Shield: Length, 3 feet 8 inches; material, No. 2 cotton canvas.

CUT 65.—The common dredge.

THE CHESTER RAKE DREDGE.

This admirable instrument (eut 66) was devised by Capt. H. C. Chester for the purpose of eollecting mollusea, annelids, crustaeea, etc., whieh burrow beneath the surface out of reach of any other apparatus in use on board vessels of the U. S. Fish Commission. The rake is shackled to the dredge rope, and a Blake dredge secured to eyebolts on the rear of its frame, follows it as it is dragged over the bottom, and

picks up whatever it turns over with its strong harrow-like teeth. Its dimensions are as follows:



CUT 66.—The Chester rake dredge.

Frame: Length, 3 feet; depth of opening, 10 inches; width of metal, $2\frac{1}{2}$ inches; thickness of metal, $\frac{1}{2}$-inch.

Teeth: Length, 7 inches; width of base, $2\frac{1}{2}$ inches; thickness of metal, base, $\frac{1}{2}$-inch.

Arms: Length of long arm, 3 feet 5 inches; length of short arm, 3 feet 3 inches; diameter, round iron, $\frac{3}{4}$-inch.

Weight, 79 pounds.

THE BLAKE DREDGE.

The ordinary dredge, having its jaws set at an angle, naturally grips the bottom and will plow into it and bury itself if the soil is light and soft. This is a necessary feature on hard, sandy bottoms, but a serious detriment in the soft ooze of the deep sea. Various devices were resorted to by Lieut. Commander Sigsbee on board the *Blake*, resulting in his "improved dredge," known aboard the *Albatross* as the Blake dredge (cut 67). The following description is from Sigsbee's Deep-Sea Sounding and Dredging:

By reason of having flaring mouthpieces and a flexible body composed of the bag and shield, the old pattern dredge is almost sure to plow deeply into yielding bottoms. Since the object sought in the fashioning of the new dredge was to effect a skimming of the bottom rather than a deep penetration therein, a very decided departure from the form of the old dredge was necessary. The frame of the new is a rectangular skeleton box made of wrought iron. The mouthpieces are flat, beveled on the forward inner edges, perforated along the rear edges, as on the old dredge, and riveted to the skeleton or bar iron portions of the framework, in which position they are held parallel.

The rear of the upper and lower sides of the skeleton are connected by three riveted braces, the whole framework being rigid. A tangle bar of heavy wood, bar iron, or iron pipe, to carry the weights and tangles, has seized to it three sister hooks, which are hooked severally around the braces and moused. The arms are like those of the old dredge, one arm being longer than the other. A netting bag and canvas shield, as in the case of the old dredge, are stitched with pliable wire to the dredge frame. A trap like that of the trawl is fitted inside the main bag. The bottom of the main bag is stopped to the middle brace at the rear of the frame. Each flap of the canvas shield is turned over and around its own side and end of the skeleton frame, and stitched to its own part with stout twine, presenting a tolerably smooth sliding surface.

The following are the dimensions of the Blake dredge as used on board of the *Albatross:*

Jaws: Length, 4 feet; width, 6 inches; thickness of metal, $\frac{3}{8}$ inch; distance of holes from edge, $\frac{3}{8}$ inch; distance between holes, 2 inches; depth or opening between jaws, 9 inches.

Skeleton frame: Length, including width of jaws, 4 feet; diameter of round iron, $\frac{1}{2}$ inch; diameter of braces, $\frac{3}{4}$ inch.

Long arm, length, 4 feet; short arm, length, 3 feet 9 inches.

Diameter of round iron, both arms, $\frac{3}{4}$ inch.

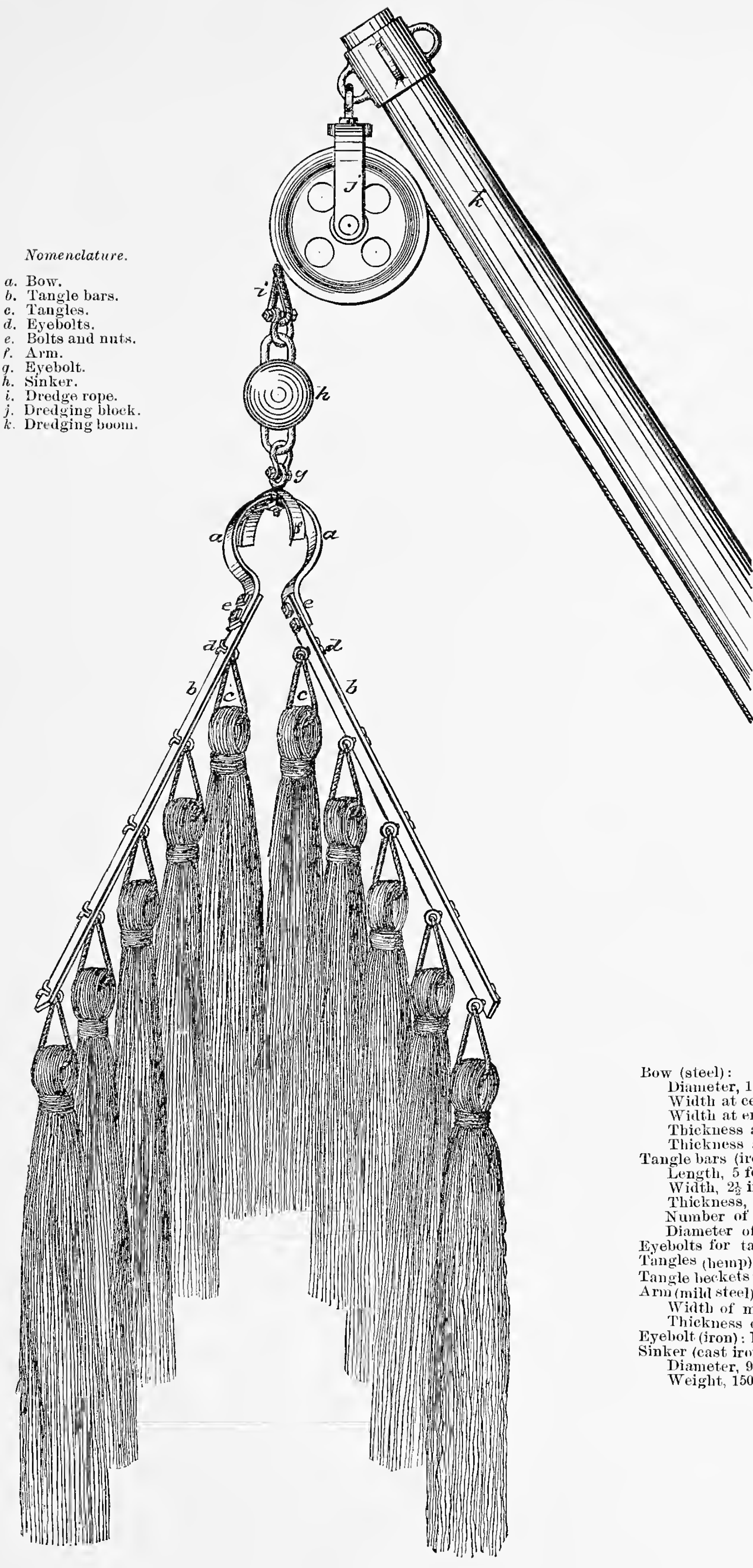
Weight of dredge and frame, 81 pounds.

Shield, cotton canvas, No. 2.

Net: Length, 5 feet; size of mesh, square, 1 inch; material, cotton, barked, 30-thread.

Jacket: Length, 3 feet; size of mesh, square, $\frac{1}{2}$ inch; material, cotton, barked, 16-thread.

Bottom lining, cheese-cloth.



Nomenclature.

a. Bow.
b. Tangle bars.
c. Tangles.
d. Eyebolts.
e. Bolts and nuts.
f. Arm.
g. Eyebolt.
h. Sinker.
i. Dredge rope.
j. Dredging block.
k. Dredging boom.

Dimensions.

Bow (steel):
  Diameter, 11 inches.
  Width at center, 3 inches.
  Width at ends, $2\frac{1}{2}$ inches.
  Thickness at ends, $\frac{1}{2}$ inch.
  Thickness at center, $\frac{1}{4}$ inch.
Tangle bars (iron):
  Length, 5 feet.
  Width, $2\frac{1}{2}$ inches.
  Thickness, $\frac{1}{2}$ inch.
  Number of holes for tangles, 5.
  Diameter of holes, $\frac{5}{8}$ inch.
Eyebolts for tangles (iron): Diameter, $\frac{1}{4}$ inch.
Tangles (hemp): Length, 4 feet.
Tangle beckets: 21-thread ratline stuff.
Arm (mild steel): Semicircular, diameter, $1\frac{1}{2}$ feet.
  Width of metal, $2\frac{1}{2}$ inches.
  Thickness of metal, $\frac{1}{2}$ inch.
Eyebolt (iron): Diameter of metal, square, $\frac{5}{8}$ inch.
Sinker (cast iron):
  Diameter, 9 inches.
  Weight, 150 pounds.

THE TANGLES.

BOAT DREDGE.

The boat dredge is essentially a miniature form of the ordinary ship's dredge already described, and is designed for use from boats where it must be worked by hand. Its dimensions are as follows:

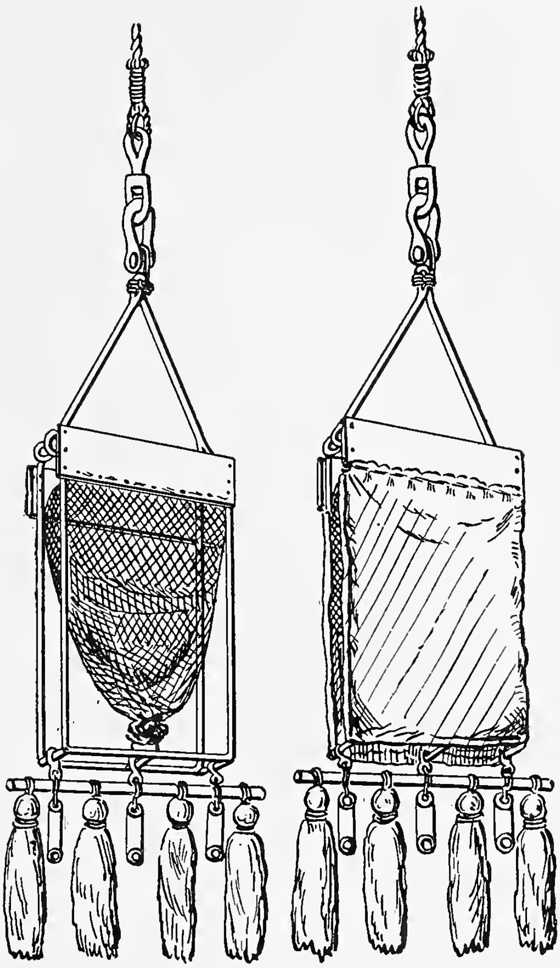
Jaws: Length, 1 foot 7 inches; width, $2\frac{1}{2}$ inches; opening, $7\frac{1}{2}$ inches; angle, 12 degrees.
Stud: Length, $6\frac{1}{2}$ inches; diameter, round iron, $\frac{5}{8}$ inch.
Bridle: Diameter, round iron, $\frac{1}{2}$ inch; length, 1 foot 5 inches.
Weight, 15 pounds.
Net: Length, 1 foot 8 inches; size of mesh, square, $\frac{3}{16}$ inch; material, cotton, 3-thread, bottom double.
Shield: Length, 2 feet 8 inches; material, No. 3 cotton canvas.

THE OYSTER DREDGE.

The oyster dredge is of the ordinary commercial pattern used in Chesapeake Bay. The rake is a flat bar of iron 6 feet in length with numerous projecting teeth. The bag is composed of a network of wire links and has a capacity of about 15 bushels. The dredge mouth is kept open by an iron frame. This dredge is used solely for the collection of mollusca.

THE TANGLES.

The present form of tangles (plate XXXIII) was devised by the writer in 1884 and they have since been used on board the *Albatross* for collecting on rocky bottoms, coral reefs, and other foul ground, capturing a great variety of specimens where no other appliance can be made available.



CUT 67.—The Blake dredge.

The bow *a* is made of spring-tempered steel and permits the bars to close with a pressure of between 300 and 400 pounds applied to their extremities, so that the apparatus will pass between rocks or other obstructions which permit the passage of the bow and sinker.

Each tangle is secured to its bar by a $\frac{1}{4}$ inch eyebolt, which draws at a tension of about 1,000 pounds, releasing its tangle when irretrievably fouled on the bottom without endangering the loss of the whole apparatus. The tangle bars are made separate from the bow and attached by bolts and nuts at *e* to secure better stowage and make the parts lighter to handle. The semicircular arm *f* is intended to raise the forward end of the tangle frame a few inches off the bottom; also to act as a shoe in

dragging over rocks or other uneven surfaces. It is held in position by the eyebolt *g*, which is square and fits snugly in square holes in the arm and bow.

The tangles are, in material, size, and structure, practically the same as the deck swabs in general use on board ship.

THE TABLE SIEVE.

The table sieve, plate XXXIV, fig. 2, is an outgrowth of the cradle sieve, fig. 1, which was formerly used for washing the contents of the dredge, the more bulky loads of the trawl having been emptied on deck. The first table sieve was devised by Capt. H. C. Chester and Prof. A. E. Verrill, and consisted of a rectangular table supporting a fine sieve, and over it the hopper with its coarse wire netting. The canvas bottom and chute were added by Mate James A. Smith, U. S. N., executive officer of the U. S. S. *Speedwell*, while in the employ of the United States Fish Commission, about 1877.

To prepare the table sieve for use, place the sieve *c* in the frame *a* on cleats provided for it a few inches above the canvas bottom *d;* then place the hopper in the frame over the sieve and carry the chute *e* to a scupper.

The table legs are now made detachable, which materially reduces the space required for stowage.

THE CRADLE SIEVE.

This sieve was devised by Prof. A. E. Verrill, in the early days of the United States Fish Commission, for the purpose of rapidly washing out the mud brought up by the dredge. It has wooden ends, nearly semicircular in form, joined by narrow strips which are let into the end pieces so as to present a smooth surface. A fine netting is drawn over the surface, and supported by an outer netting of coarse mesh secured firmly to the ends and side pieces. An inner sieve with coarse mesh rests on and partially inside of the main sieve. It is intended to be hung over the vessel's side by means of a rope bridle attached to iron straps on the end pieces.

THE STRAINER.

The strainer, fig. 3, was introduced on board the *Albatross*, in 1883, by Mr. James E. Benedict, resident naturalist, for the purpose of straining all water used for washing mud and ooze from specimens in the table sieve. By this means minute forms of crustacea, annelids, foraminifera, etc., are recovered at small expense of time and labor.

Its construction is very simple. An oil barrel was cut down until it would slide under the table sieve. Three iron drain-pipes are inserted in the side, one diagonally over the other, and attached to them are three strainers, *a*, *b*, and *c*, made of linen scrim, through which the water is drained as it rises successively to the level of each. The combined areas of the three are sufficient to carry off the water supplied by the steam hose under ordinary circumstances. When it is to be used in connection with the table sieve the long chute *e* is removed, and a short one about a foot in length is substituted, the water being discharged directly into the strainer.

THE TANNER IMPROVED DREDGING QUADRANT.

The dredging quadrant (plate XXXV) in its original form was designed by the writer as the most convenient and practical method of ascertaining the position of trawl or dredge in deep-sea exploration by observing the angle of the dredge rope. The present form is simply a refinement of the original.

Dimensions of cradle sieve.

Length, 3 feet.
Breadth, $1\frac{1}{2}$ feet.
Depth, 1 foot.
Width of side pieces, $3\frac{1}{2}$ inches.
Thickness of side pieces and ends, 1 inch.
Depth of inner sieve, 8 inches.

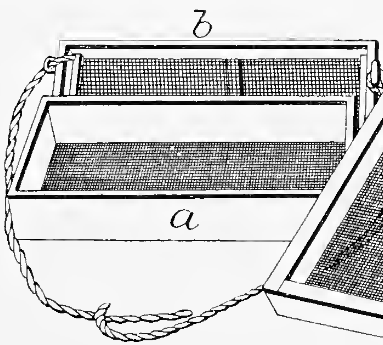


Fig. 1. CRADLE SIEVE.

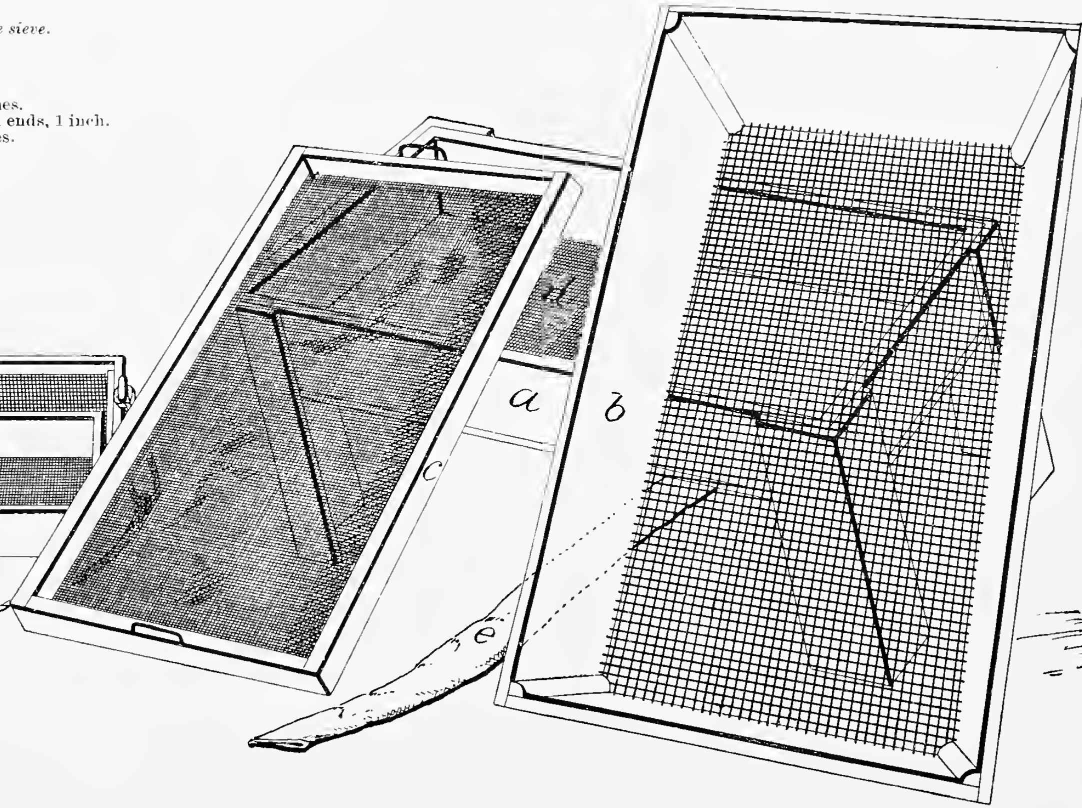


Fig. 2. TABLE SIEVE.

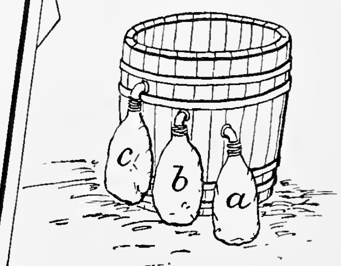


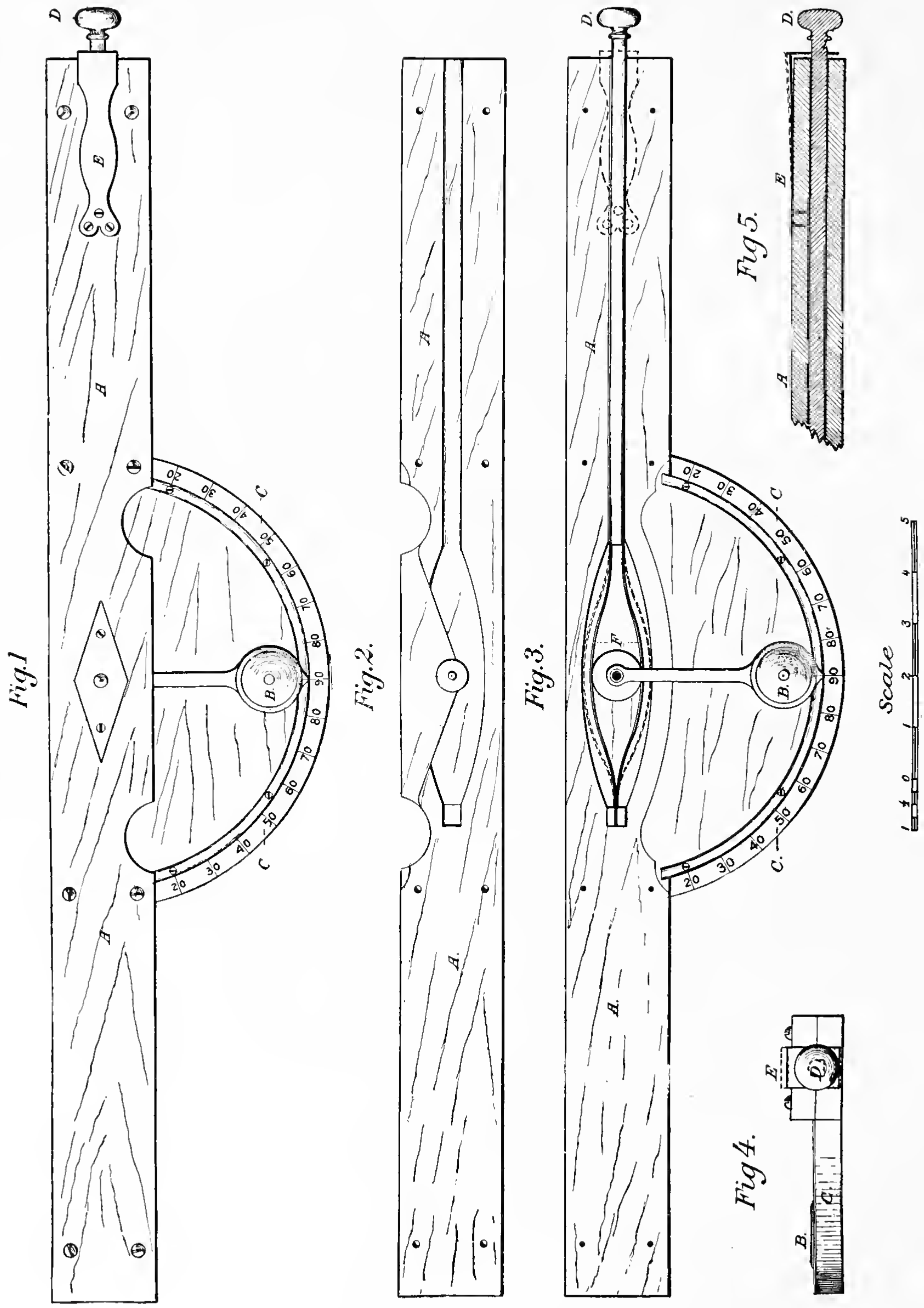
Fig. 3. STRAINER.

Dimensions of table sieve.

Table frame:
  Length, 5 feet 6 inches.
  Breadth, 3 feet 2 inches.
  Depth, 1 foot.
  Height from deck to top of frame, 3 feet 2 inches.
  Thickness of planks, 1 inch.

Hopper:
  Length, top, 5 feet 9 inches; bottom, 4 feet.
  Width, top, 3 feet 5 inches; bottom, 2 feet 6 inches.
  Depth, 1 foot 1 inch.
  Thickness of planks, 1 inch.
  Size of mesh, galvanized-iron wire netting, $\frac{5}{8}$ inch.

Sieve:
  Length of frame, 5 feet 3 inches.
  Breadth, 2 feet $11\frac{1}{2}$ inches.
  Depth, $2\frac{1}{2}$ inches.
  Thickness of planks, $1\frac{1}{2}$ inches.
  Size of mesh, galvanized-iron wire netting, $\frac{1}{12}$ inch.
Bottom. No. 4 cotton canvas.



THE TANNER IMPROVED DREDGING QUADRANT.

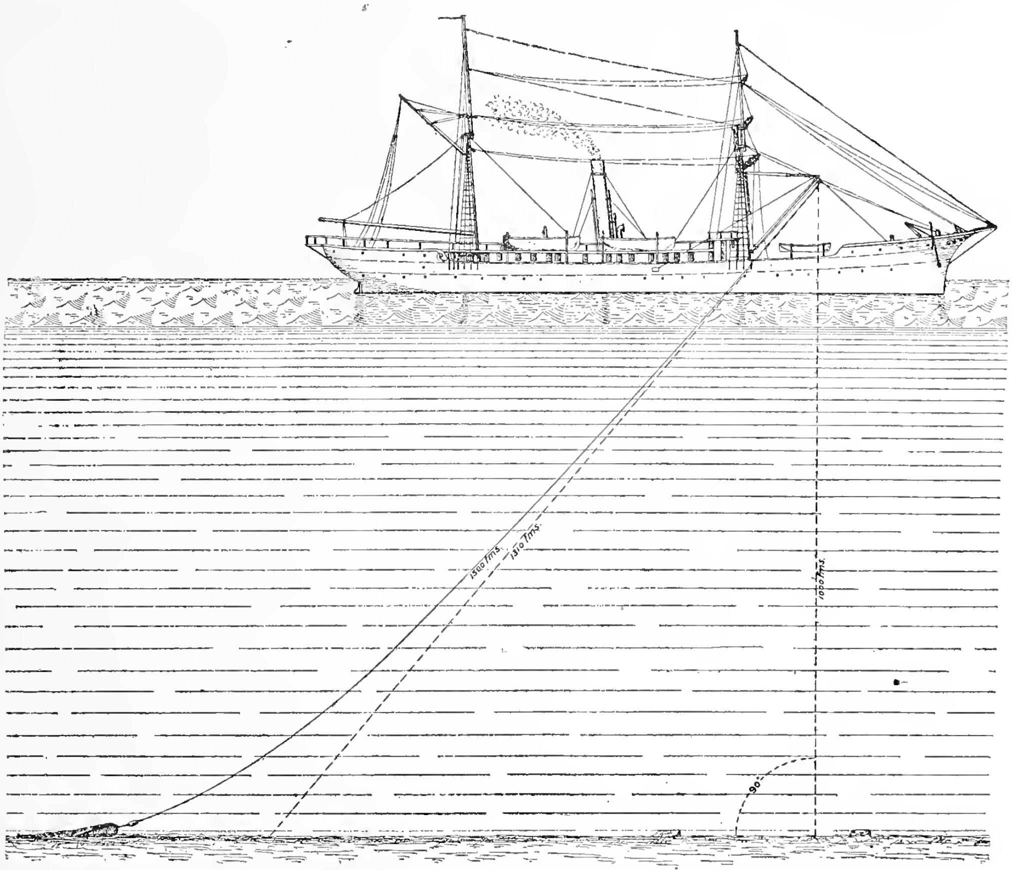
Fig. 1. Instrument ready for use.
Figs. 2. and 3. A sectional view.
Fig. 4. End view at D.
Fig. 5. Sectional view of the rod D, frame A, and spring E.

Nomenclature: A, Frame. B, Pendulum. C, Scale. D, Rod. E, Spring catch. F, Elliptical spring.

The frame A is composed of two pieces of black walnut, or other suitable wood, each 2 feet in length, 2 inches wide, and ½ inch thick, scored on their inner surfaces to receive the rod, springs, and pendulum.

The back part of the frame has a semicircular projection, to which the scale C is secured. The pendulum B is of brass, 4 inches in length, weighted with lead at its lower end to insure prompt action. There is a disk at its upper extremity with a milled surface, and it is suspended on friction bearings which allow it to swing freely.

The rod D has a knob on its outer end for convenience in working, and to its inner end is attached the elliptical spring F, composed of spring brass, which is intended to



CUT 68.—The angle and scope of the dredge rope.

grip the milled head of the disk and hold the pendulum securely in place whenever the notch in the rod D is freed from the spring catch E. To release it from the embrace of the spring, press on the knob with the palm of the right hand until the notch in the rod D is engaged by the slot in the spring catch E; the elliptical spring F is thus distended, the friction removed from the disk, and the pendulum given unobstructed movement.

The scale C is of brass, secured to the frame by brass screws; it is graduated on both sides from 20° from the perpendicular to 90° or horizontal, so that it can be used on either side of the vessel, whether backing or going ahead. A guard of round

brass rod is secured inside of the scale to strengthen the frame and prevent its warping, also to protect the pendulum point which swings between it and the scale.

To use the dredging quadrant grasp it in both hands, straight edge up, knob to the right; see that the pendulum swings freely; then take a favorable position (cut 68), cast the eye over the straight edge of the quadrant, inclining it to the angle of the rope, at the same time sweeping it back and forth until they are parallel; then lock the pendulum by pressing the spring catch E with the thumb of the right hand. The angle of the rope from the perpendicular may then be read from the scale.

The following illustrative example explains the principle of the dredging quadrant and its practical application:

Given the depth, 1,000 fathoms, and the angle 40°, what is the scope of dredge rope required to insure the landing of the trawl on the bottom?

Enter Table II, Bowditch, or any table for the solution of plane right triangles, with 40° as a course, and find the depth, 1,000 fathoms, in the difference of latitude column (taking one-tenth of the amount), 100.4 being the nearest number. Opposite to this, in the distance column, is 131, which being multiplied by 10 gives 1,310 fathoms, the hypotenuse of the right triangle we have constructed. As the rope has a catenary curve it is necessary to make an allowance in order to insure the trawl reaching and remaining on bottom. Experience teaches that about 200 fathoms is sufficient with above depth and angle; therefore, with a scope of 1,500 fathoms, and the angle of the rope maintained between the limits of 35° and 40°, a successful haul may be anticipated so far as the landing of the trawl on the bottom is concerned.

The speed at which it can be dragged varies from 2 to 2½ knots per hour, depending upon the state of the sea, the currents, and the character of bottom. It can be regulated after a little practice so as to confine the angle of dredge rope within the limit of 5°; hence there is a wide margin as to its scope, which is governed largely by the speed at which it is desired to drag the trawl or dredge over the bottom.

SURFACE AND INTERMEDIATE COLLECTING.

The surface tow net was among the first devices of the naturalist for collecting minute animal and vegetable forms on the surface, and the same apparatus has been used at intermediate depths, although its range was confined within narrow limits, usually but a few fathoms, and even then it was not entirely satisfactory, as specimens would naturally find their way into the net while it was being hauled to the surface, the exact depth of their habitat remaining a mystery.

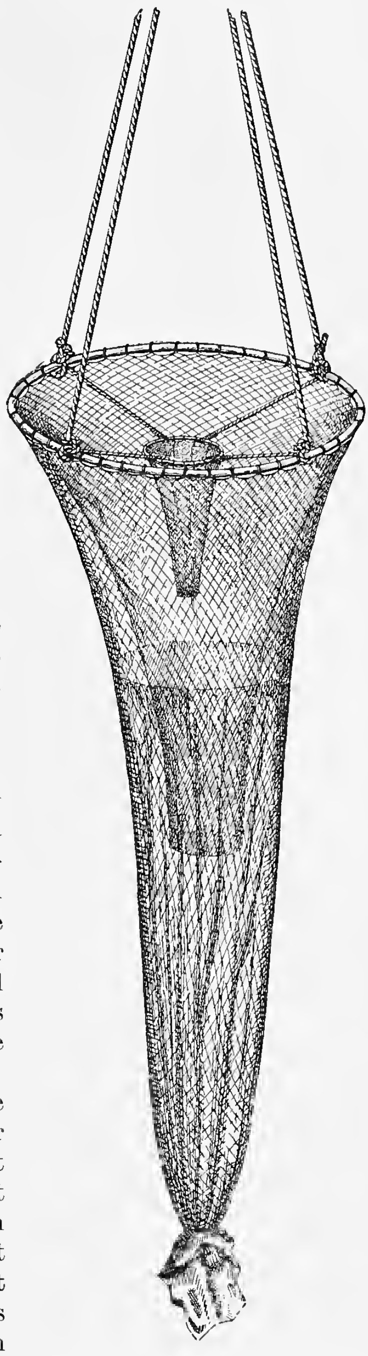
The ring of the surface tow net in common use is from 12 to 18 inches in diameter, made of ¼-inch iron or brass rod. The best nets are of silk gauze, or bolting-cloth, although they may be made of cheese-cloth or other suitable material. They are usually towed with a small line either astern or over the side when the vessel is moving slowly through the water.

The dip net has been in constant use on board the *Albatross*. Its ring resembles that of the surface tow net, but is usually made of heavier wire, and it has a shank which is inserted into a staff, preferably a bamboo pole of sufficient length. The net is of silk bolting-cloth.

This device may be used at any time when the vessel is lying without headway or moving very slowly through the water. Its greatest achievements have been in connection with the electric light. At night, preferably from one to three hours after dark, the vessel lying broadside to the wind and without headway, an ordinary

Edison 50-candle incandescent lamp, attached to a properly insulated cable, is lowered from the lee gangway, 6 feet or more from the ship's side, just sufficiently to keep it submerged with the ordinary motions of the vessel. Slow-moving forms which are floating on the surface collect in large numbers at the water line as the vessel sags slowly to leeward and more active species gather to feed upon them. As soon as the light is lowered, the latter gather around it, as moths about a candle, sometimes in great swarms, and it is then that the net reaps its richest harvests.

Surface collecting has always been a marked feature in the work of the *Albatross*, and improved methods were sought from the first. The opportunities for this line of investigation, without interfering with other work, were unprecedented, as the net above described could be used whenever the vessel was hove to for sounding, etc., and the tow net was available from the time the trawl was put over the rail until it was on board again, from half an hour to six or eight hours later. Observing this, it seemed that something might be done to develop this field of inquiry, and various devices were tried from time to time with greater or less success until, on the 8th of May, 1885, the present form of surface tow net, devised by the writer, was first used and became a part of the regular scientific outfit.



CUT 69.—Improved surface tow net.

IMPROVED SURFACE TOW NET.

The ring is of $\frac{5}{8}$-inch galvanized iron, 4 feet $1\frac{1}{2}$ inches in diameter; the net has a $\frac{1}{2}$-inch mesh, thread 24–6 stow, barked, 10 feet in length, same size throughout, and has a pocket of the same material 5 feet in length, which is formed by turning in a portion of the upper end of the net, thus doubling the material for 5 feet from the ring. A small cord is passed around the net between the parts, and is included in the turns of the lashing which secures the net to the ring. There is a drawstring in the lower end of the pocket.

A mosquito-net lining is secured on the lower inside portion of the net, and hangs a foot below it, in order that it may have sufficient slack to insure the outer net taking the strain of towing. An ordinary surface net with 12-inch hoop and a silk-gauze bag, 20 inches in length, is suspended in the mouth of the larger net by four bridles of small stuff secured to the ring; it is intended to collect minute forms that might pass through the coarser material of the large net. A $2\frac{1}{2}$-inch manila rope bridle with four legs is secured at equal distances around the ring, and a 3-inch rope hitched through the bight is used for towing.

In preparing the net for use it is advisable to lash the lining separately as near the end as practicable and place it inside of the net, lashing the end of the latter in such a manner that the former will rest entirely upon it, relieving the more delicate material from the strain of towing; otherwise it will be ruined by the great volume of water passed through it. It is towed from the swinging boom at about 2 knots per hour, and, when the vessel is engaged solely in surface collecting, two nets are used at the same time, one at each boom.

TOW NETS FOR INTERMEDIATE DEPTHS.

A large tow net was devised by the writer, at the instance of Professor Baird, for the purpose of taking fish at the surface and at intermediate depths. It was used for the first time on May 8, 1883.

The ring was made of 1-inch round iron, and was 10 feet in diameter; the net, 1-inch mesh and 20 feet in length; the bridle had four legs, which were seized at equal distances around the ring, and the steel-wire dredge rope was used as a tow line.

This apparatus was towed at various depths, from surface to bottom, at speeds ranging from 2 to 7 knots per hour, but it failed utterly in so far as the capture of pelagic forms was concerned; any fish which had sufficient celerity of movement to escape a beam trawl would avoid this net. The trouble seemed to arise from its "firing," for when used at night its tracks several fathoms below the surface could be distinctly seen. On one occasion, when a school of mackerel was attacked with it on a dark night, we could see the mass separate only a few feet in advance and then promptly close again in its rear, and not one was caught. The school was so dense that it seemed impossible to drag so large a net among them without catching one or two at least; but after an hour or more of towing in every direction at varying speeds from 1 to 8 knots, without the capture of a single specimen, we gave it up as a failure.

Surface tow nets attached to the dredge rope were used on board the *Challenger* for intermediate collecting, but a knowledge of the depths at which the specimens were secured was still lacking. The same practice was followed on board the *Fish Hawk* until we improved upon it by adopting wing nets, which were attached to each end of the trawl beam, and performed the functions of collectors from surface to bottom, and thence to the surface again. They were like an ordinary surface tow net with a pocket added. The material was cheese-cloth, and being much finer than any portion of the trawl which they accompanied, they usually contained a miscellaneous collection of small forms, many of which would not have been secured by any other method in practice at that time. Of course, we had little knowledge of the depths at which the various forms were secured. Such as were common to both wing net and surface net were, in a general way, assigned to areas within the influence of sunlight, while those found in the wing nets alone were allotted to depths more profound.

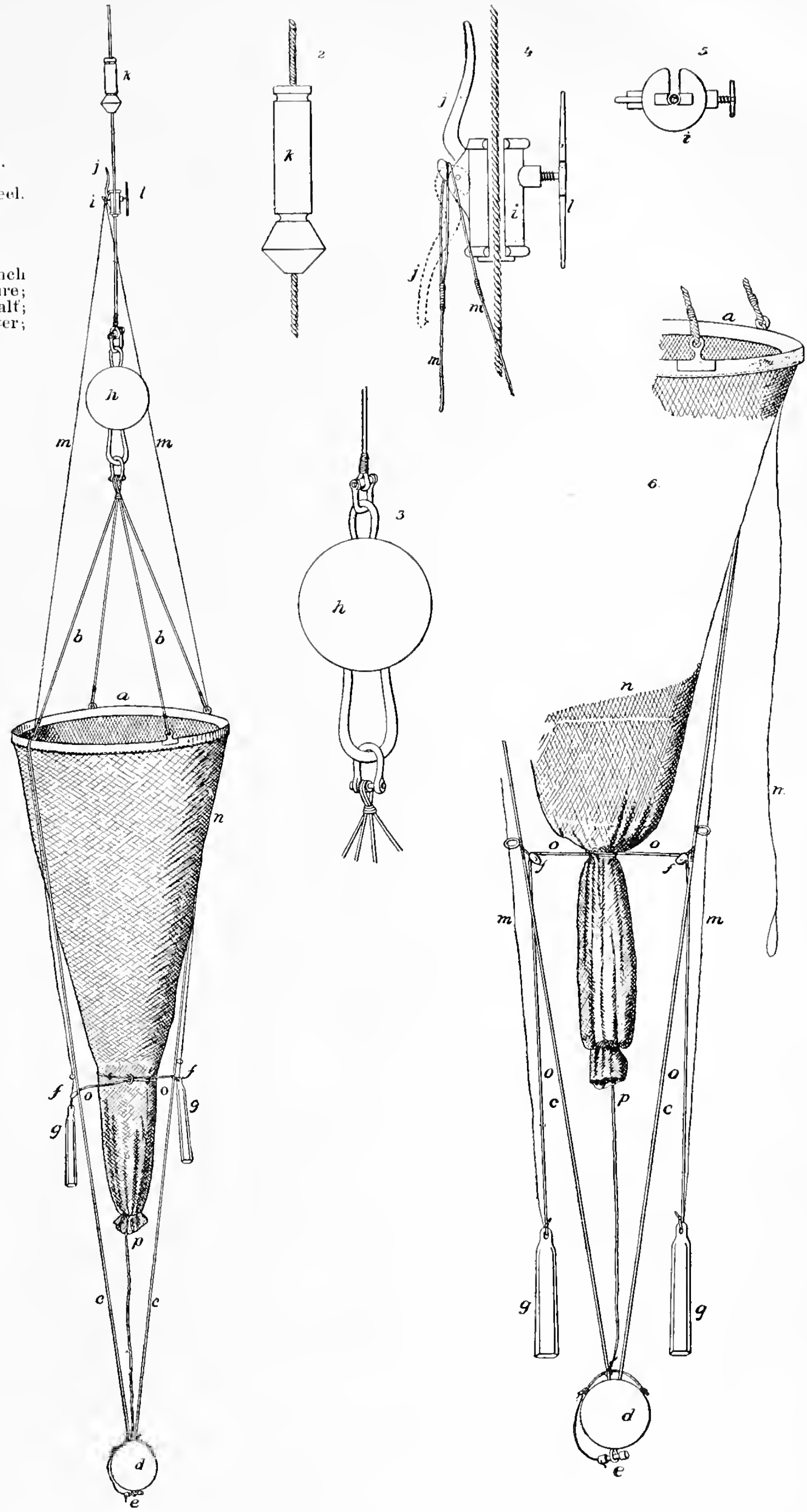
THE TANNER INTERMEDIATE TOW NET, FIRST PATTERN.

This net (plate XXXVI) was improvised at sea from materials at hand after the failure of other apparatus. Its purpose is to collect animal life from known intermediate depths, and although it has been superseded by a later pattern it is reproduced as a guide to others who may wish to construct a similar net with the slender resources usually available on shipboard.

The ring *a* is of brass, 2 feet 9 inches in diameter, with a four-legged bridle *b*, secured to eyes spaced at equal distances around it and shackled to the lower link of

Nomenclature.

a. Ring, brass.
b. Bridle, ratline stuff.
c. Lower bridle, 2-inch manila.
d. Sinker, 60-pound sounding shot.
e. Toggle, wood.
f. Blocks for draw string, brass.
g. Weights for operating draw-string, lead.
h. Sinker, cast iron, with wrought links.
i. Friction clamp: frame, brass; tumbler, steel.
j. Tumbler.
k. Messenger, cast iron.
l. Wrench, steel.
m. Tripping-lines, cod line, cotton or flax.
n. Net, cotton thread 24-6 stow barked, ¼-inch mesh (square), ½-inch stretch measure; first lining, mosquito net lower half; second lining, silk gauze lower quarter; guide rings for drawstring, brass.
o. Drawstring braided cord or cod line.
p. Lashing, cod line.



THE TANNER INTERMEDIATE TOW NET, FIRST PATTERN.

FIG. 1. Apparatus ready to be sent down. The messenger *k* is also shown on the tow line, above the friction clamp *i*.

FIG. 2. Enlarged view of messenger, showing scores in which the lashings are placed to hold the two parts together when it is sent down.

FIG. 3. Enlarged view of sinker, with links and shackles, showing the manner of attaching the tow line and net.

FIG. 4. Side view of friction clamp *i*, with tumbler *j* and wrench *l*.

FIG. 5. End view of clamp *i*.

FIG. 6. Enlarged view of net, showing the lower part closed as follows: The messenger was sent down and its impact overturned the tumbler, released the tripping lines, which allowed the weights to fall, and by their weight bring sufficient strain on the drawstring to close the bag as shown.

the sinker *h*. The dredge rope is shackled to the upper link and serves as a tow line. The lower bridle *e* has two legs, each 10 feet in length, of 2-inch manila rope, the free ends seized to opposite sides of the ring and a 60-pound sounding shot toggled to the lower end as a sinker to insure the apparatus going down vertically. The net *n* is cylindrical in form, 5½ feet long, the lower half lined with mosquito net and the lower third with an additional lining of silk bolting-cloth. The tail lashing *p* having been adjusted, one end is carried down and made fast to the lower bridle at *d* to keep the net in place while it is being lowered.

Four small brass rings are stitched to the net at equal intervals, a few inches below the upper edge of the silk lining, through which is rove a drawstring of braided signal halyard stuff, or soft white cod line, which makes a round turn, the ends being finally passed in opposite directions through the same ring, rove through blocks on the bridle legs and bent to the weights *g*, which weigh 14 pounds each. Two tripping lines *m*, of cod line, with eyes in their upper ends, are hooked over the tumbler *j* of the friction clamp *i*; the other ends are passed down through leads on the ring *a* and bridle legs *c*, and bent to the weights *g*, suspending them at the height of the drawstring blocks, allowing the drawstring to hang loosely about the net and the latter to retain its natural form while going down and until it is closed by the action of the messenger.

To use the net, prepare it as in fig. 1, lower it vertically, from 20 to 25 fathoms per minute, until it reaches the desired depth, and tow it from 1½ to 2 knots per hour, heaving in, veering and varying the speed, in order to maintain it at the proper depth, which can be determined within a few fathoms by observing the angle of the towline with the dredging quadrant.

To recover the net, stop and back until the towline is vertical, heaving in during the operation in order to maintain the net at the same depth at which it had been towed; then send the messenger down to act on tumbler of friction clamp, release tripping lines, and close lower part of net (fig. 6). The messenger is in two parts, which are held on the towline by seizings of marline. It sinks from 100 to 110 fathoms per minute, and the impact can usually be felt by grasping the towline. When the lower net is closed, steam ahead at the usual towing speed and heave in at the rate of 25 to 28 fathoms per minute, according to the state of the sea.

The net has been used successfully in 1,700 fathoms, yet it was looked upon as a makeshift. Its principal weakness was due to the action of the sinker *d*, which was necessary in lowering, but caused the net to tow at such an angle that the useful area of the ring was greatly reduced, whereas fully three-fourths of the area is operative in the improved pattern.

THE TANNER INTERMEDIATE TOW NET, IMPROVED PATTERN.

This apparatus (plate XXXVII) is the same in principle as that already described, and its function, the collection of animal life from known intermediate depths, is also the same, but its efficiency and certainty of action are increased, and it is more easily operated. Its frame is composed of brass pipe and fittings of commercial pattern, carrying a net so arranged with drawstring, movable weights, tripping lines, friction clamp, and messenger that its lower part can be closed at will.

General description.—The ring *a* is 2 feet 5 inches inside diameter, composed of brass pipe $1\frac{1}{16}$ inch outside diameter, bent in a circular form, the ends joined by a union. On the ring are four tees, two on each side, spaced 6 inches apart, and secured

in place. The half of the ring opposite the union is filled with lead, which gives it a preponderance of about 10 pounds.

The arms b are of brass pipe of the same diameter as that of the ring; the lower ends are screwed into tees which move freely on the ring between those above mentioned, the upper ends having a hinge joint held in place by the shackle pin.

The legs e, four in number, are also of brass pipe, $\frac{13}{16}$ of an inch outside diameter and 5 feet $5\frac{1}{2}$ inches total length, with net length (from lower side of ring to apron) of 5 feet. The lap of legs over the apron is $4\frac{1}{2}$ inches, and the upper ends screw 1 inch into their respective tees.

The apron d is of sheet brass $\frac{1}{8}$ inch thick, 18 inches in length; straight on the upper edge, the lower part semicircular with a radius of 10 inches. It is secured to the flattened extremities of the legs by two screwbolts *e* in each end, $\frac{5}{16}$ inch in diameter and $2\frac{1}{4}$ inches in length. An oblong hole in the central upper part of the apron is for the purpose of securing the tail of the net, in order to prevent its floating up or becoming entangled while being lowered.

The functions of the apron are threefold: First, to afford rigid and secure fastenings for the lower ends of the legs; second, by its form to aid in guiding the net down vertically when lowering, and, finally, to give the apparatus a tendency to take a horizontal position when towing, thus increasing the area of collecting surface within the ring. The heavy weights are all at or near the ring while the net is being lowered and towed, and there is a preponderance of 70 pounds on one side of it, so placed as to cause the apron to expose its flat surface to the water and greatly increase the tendency of the light rear end to seek the level of the more ponderous weighted ring whenever it is moving forward.

Blocks f, four in number, for operating the drawstring, are of brass, $1\frac{1}{4}$ inches in length. Two of them are secured to a pair of legs by through bolts, riveted 2 feet 4 inches above the apron; the others are seized with wire to the tees holding the upper ends of the other pair of legs, upon which the movable weights traverse.

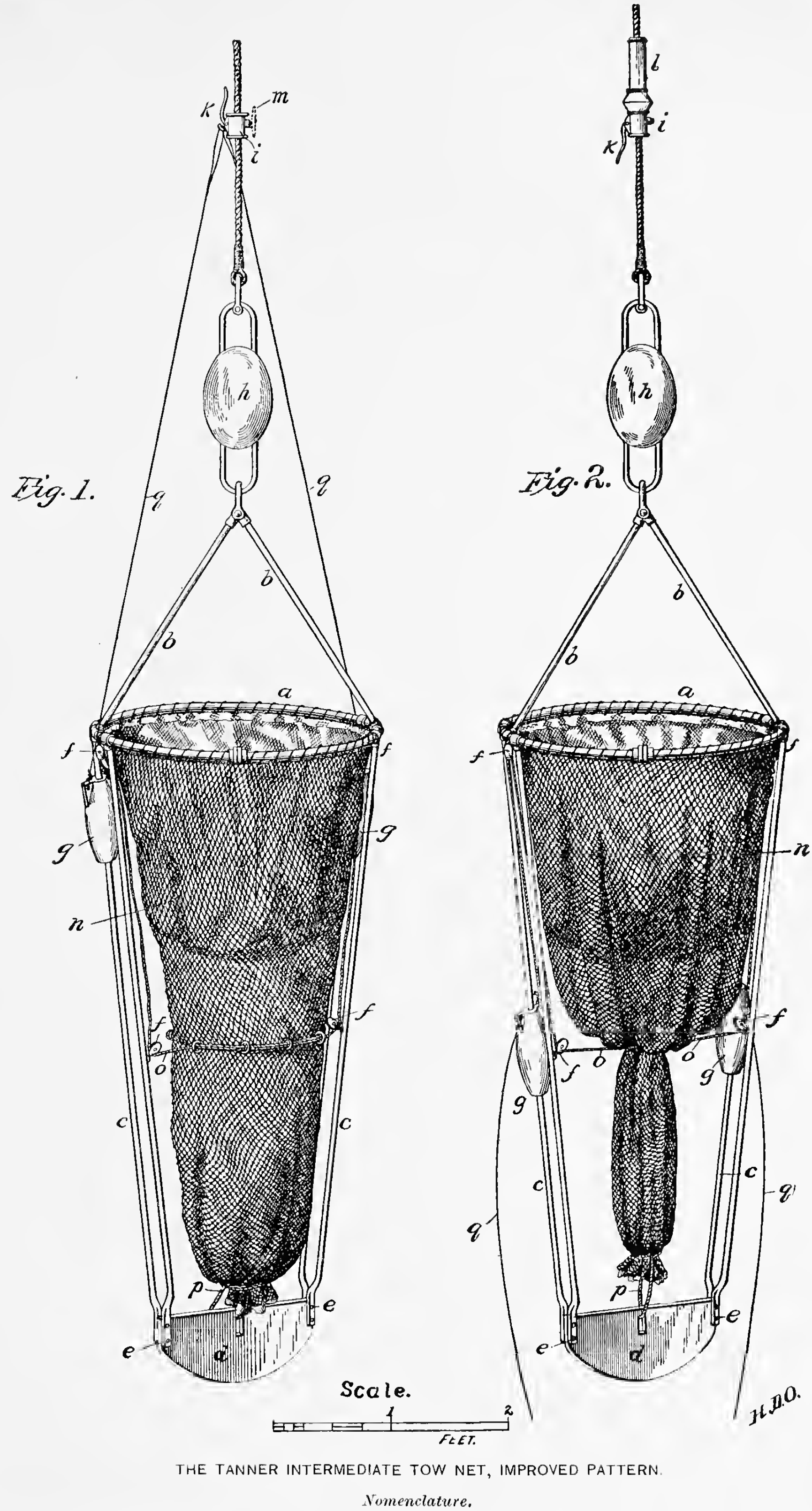
The movable weights g, of lead, two in number and weighing 30 pounds each, are provided to put the required tension on the drawstring when it is desired to close the net. They are egg-shaped, 4 inches in diameter by 9 inches long, and have an inch hole through the center; $\frac{3}{8}$-inch holes in lugs at their upper extremities furnish a convenient method of attaching the drawstring and tripping lines.

The sinker h is of cast iron, 130 pounds weight, oblong in form, with projecting links of wrought iron at each end, through which shackles for attaching tow net and dredge rope pass. The sinker is used to facilitate lowering the net, and to prevent kinking the steel dredge rope or tow line.

The friction clamp i is composed of brass and steel, the barrel of the former metal, the eccentric tumbler *k*, sliding chocks, striking face, and adjusting screw of the latter. A small steel wrench *m* is provided to work the adjusting screw.

The messenger l is of cast iron, 9 pounds in weight, made in halves, with two scores on the external surface for convenience in passing lashings. To use it, pass the halves over the rope and take a few turns of a lashing. The hole in the messenger is sufficiently large to allow it to pass freely over splices in the dredge rope.

The net n is $\frac{1}{4}$-inch square mesh; thread 24–6 stow, barked; it is seized to the ring with seine twine, and hangs 5 feet 6 inches in length, the same size throughout. It is lined with mosquito netting the whole length, and there is an inner lining of silk gauze extending up 3 feet 6 inches from the lower end. The outer net is intended to



THE TANNER INTERMEDIATE TOW NET, IMPROVED PATTERN.

Nomenclature.

a. Ring, brass pipe.
b. Arms, brass pipe.
c. Legs, brass pipe.
d. Apron, sheet brass.
e. Apron bolts, brass.
f. Blocks for drawstring, brass.
g. Weights for drawstring, lead.
h. Sinker, cast iron, with wrought links.
i. Friction clamp, frame brass.
k. Tumbler, steel.
l. Messenger, cast iron, in two parts.
m. Wrench, steel.
n. Net, ¼ inch square mesh.
o. Drawstring, braided cord.
p. Tail lashing, cod line, cotton.
q. Tripping lines, cod line, cotton or flax.

take the strain in towing, the linings pressing against it on all sides and acting simply as collectors. The lower end of the net is closed by a cod-line lashing *p*, which includes the outer net and mosquito-net lining, the silk gauze or inner lining being secured separately and placed inside of the others as an additional protection against wear and tear. After the outer net is securely lashed, the ends of the same lashing are taken through the hole in the apron and knotted, leaving about 6 inches slack to allow for closing the net, shrinkage, etc.

Six guide rings of $\frac{3}{16}$-inch brass wire and 1-inch diameter are secured at equal intervals around the outer surface of the net *n*, to support the drawstring *o*. They are placed about 2 inches above the blocks *f* on the legs *c* in order to allow the net to close without bringing undue strain upon its upper body.

The drawstring o is a braided cord 13 feet in length and $\frac{1}{4}$ inch diameter, used to close the lower part of the net *n* after towing and before it is hoisted to the surface. Cod line, or other material of the proper size, will answer the purpose, but braided cord is preferred as less liable to kink while lying loosely during the process of lowering and towing; moreover, it presents a smooth surface to the net, reducing the wear on the web caused by repeated opening, closing, towing, and hoisting.

The tripping lines q, two in number, are of cod line, 9 feet 6 inches in length, with 7-inch loops or eyes on their upper ends.

To assemble the apparatus: The ring being intact, with the arms lying side by side across it, their lower ends attached to their respective tees, raise the arms and shackle the sinker in place. Shackle the tow line, or dredge rope, to the other end of the sinker, and suspend the ring at convenient height; screw the legs into their respective sockets, which will be recognized by marks of a center punch, $\div$ $\frac{\cdot\,\cdot}{\cdot\,\cdot}$ $\frac{\cdot\,\cdot\,\cdot}{\cdot\,\cdot\,\cdot}$ $\frac{\cdot\,\cdot\,\cdot\,\cdot}{\cdot\,\cdot\,\cdot\,\cdot}$; then place the apron in position and secure it by the screwbolts. The movable weights *g* are carried on the pair of legs nearest the weighted side of the ring, the lower drawstring blocks being on the other pair farthest from it.

Seize the net to the ring, run the drawstring through the small rings on the body of the net, taking a round turn and an overhand knot, then run the ends through the lower and upper blocks and hitch them to the movable weights through holes in their lugs; hitch the ends of the tripping lines through remaining holes in the lugs, place the friction clamp on the rope, slip the loops over the lip of the tumbler, and slide the clamp up the rope until the weights are suspended about 4 inches below the ring and tighten the adjusting screw with the wrench, keeping the tumbler elevated and pressed against the rope until the clamp grips it with sufficient force to hold it in place. It should not be secured too firmly, as it is intended that it should slide down the rope with the messenger after the impact of the latter has reversed the tumbler.

Having ascertained the point on the rope at which the clamp should be secured it may thereafter be attached in the same place without further attention to the tripping lines, which may be hooked over the lip of the tumbler and the weights suspended at the proper distance below the rings, by simply taking in a trifle more or less at the hitch.

The length of tripping lines, 9 feet 6 inches, is intended to give sufficient drift for the weights to close the net even if the clamp slips down the rope without the tumbler having been capsized. A single weight will securely close the net if from any cause the other fails to act.

To use the net, having assembled it as directed, overhaul the drawstring until the net hangs entirely free; bring the vessel to a dead stop and lower away at the rate of 25 fathoms per minute until the depth is reached. Then, having determined upon the

angle at which it is to be towed, enter Table II, Bowditch Navigator, and find the length of rope required to maintain the net at the proper depth and steam ahead slowly, veering gently until the predetermined scope and angle are attained. The latter can then be maintained with sufficient accuracy by frequent observations with the dredging quadrant and properly regulating the speed.

A correction, to be subtracted from the figures taken from Table II, Bowditch, will be required for the catenary curve, as the sinker and the net being afloat at an intermediate depth will sink more rapidly than the rope which is being dragged laterally from 150 to 200 feet per minute through the water. It is quite impossible to give an invariable rule for making this correction. It may be said, however, that the angle of 40° has usually been adhered to on board the *Albatross*, which involves a speed of 2 knots per hour, approximately. Under these conditions a deduction of 8 fathoms per 100 fathoms in depth may be made up to 500 fathoms; 9 fathoms per 100 between 500 and 1,000 fathoms; and 10 fathoms per 100 between 1,000 and 2,000 fathoms.

This approximate rule is applicable to the stated conditions only, but will serve as a general guide until the explorer learns from experience the corrections required by his own methods and apparatus.

ILLUSTRATIVE EXAMPLE.

Depth at which the net is to be towed	500 fathoms
Angle of the tow rope	40°
Length of rope required, Table II, Bowditch	650 fathoms
Correction for catenary curve, 8 fathoms per 100 fathoms depth	—40 fathoms
Length of tow rope required	610 fathoms

To recover the net, having towed it a sufficient length of time, stop the engines and back slowly until the tow rope hangs vertically, reeling in sufficient rope to maintain the net at a uniform depth; send the messenger down and release the weights by reversing the tumbler, when they will exert a sudden and sufficient force on the ends of the drawstring to securely close the lower part of the net.

The messenger sinks at the rate of 100 to 110 fathoms per minute, and its impact can usually be felt by grasping the rope, but this method is not always reliable, hence it is advisable to use time intervals, allowing the safe limit of 100 fathoms per minute.

Having closed the lower bag, steam slowly ahead and reel in at the rate of 25 to 28 fathoms a minute until the net is on board. The upper portion from the mouth to the drawstring remaining open, will usually be found to contain an assortment of specimens collected on the way up.

A few turns of a lashing should be taken around the net immediately below the drawstring as soon as possible after the apparatus reaches the deck and while it is hanging vertically by the tow rope, to avoid the possibility of opening communication with upper and lower compartments by the accidental slackening of the drawstring. This done, the frame should be lowered gently on deck, the lashing removed from the tail of the net and the parts turned back, leaving the inner or silk gauze lining exposed; remove its lashing, carefully open the bag over a pan of prepared sea water which has been carefully strained to remove any surface forms it might have contained, and finally rinse the net in it to remove minute specimens adhering to its sides or lodged in the numerous folds.

The contents of the lower bag secured, the drawstring is removed, the upper bag turned inside out into a tub of water, and the specimens secured by thorough rinsing, after which the lashing is taken off and the net carefully washed, usually by towing

a few minutes if the vessel should be moving slowly through the water; otherwise by washing and repeated rinsings until all trace of life is destroyed. The last rinsing should be in fresh water, and the frame should be wiped off to prevent oxidation.

If the apparatus is to be stowed away, remove the apron, unscrew the legs, and hang the ring with net attached in a convenient place to dry. The tripping lines and the drawstring should be hitched to arms or rings and dried. When ready to store, reeve the drawstring in place, roll the net up snugly, and stop it with the ends of the drawstring; remove the shackle pin and fold the arms across the ring, using the tripping lines to hold them in place and to confine the net as far as possible within the ring, thus making a snug and convenient package.

FISHING GEAR.

The cod hand lines used aboard the *Albatross* are a modification of the *Georges* gear, and may be described as follows:

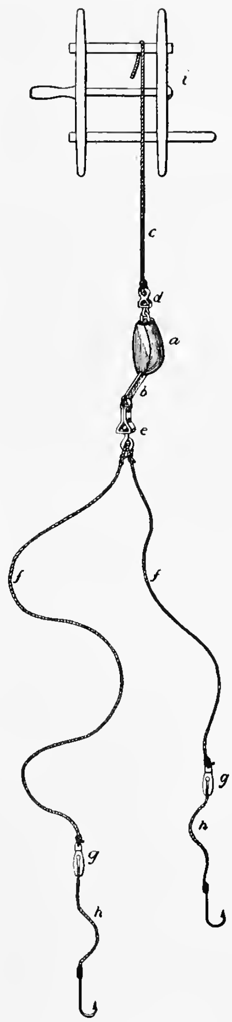
The material for hauling lines is received in lengths of 25 fathoms and weighs 18 pounds per dozen or 300 fathoms. A full-length hand line is composed of six 25-fathom lines spliced together. The *Albatross* has a few of these which are coiled in tubs, while those of 50 and 75 fathoms are carried on hand reels.

Tarred cotton, 10 to 14 pounds per dozen lengths of 25 fathoms each, is used for snoods. There are two on each line secured to the swivel on the bight, one leg 6 feet in length, the other about 4 feet. Their lower ends are attached to hook swivel slots either by a wall knot or by splicing.

The gangings are composed of a single strand of hemp line, about the size of the hauling line, secured to the hooks by hitching the bights around their shanks, then laying the two parts together and making wall knots on the ends, by which they are secured to the hook swivel slots. No. 14 cod hooks are in general use on the trial lines, although other sizes are used as occasion requires.

The following is a list of the fishing lines that are kept in readiness for use:

- Squid lines.
- Whiting lines.
- Cod hand lines, 2, 3, and 4 pound leads.
- Red-snapper lines.
- Bluefish lines, for trolling.
- Sea-bass lines, style used in Southern States.
- Sea-bass lines, style used by New York smackmen.
- Bluefish lines, for still baiting.
- Shark lines.
- Cod trawl lines.
- Halibut trawl lines.
- Haddock trawl lines.
- Mackerel hand lines.



Cut 70.—Cod hand line.

Nomenclature.

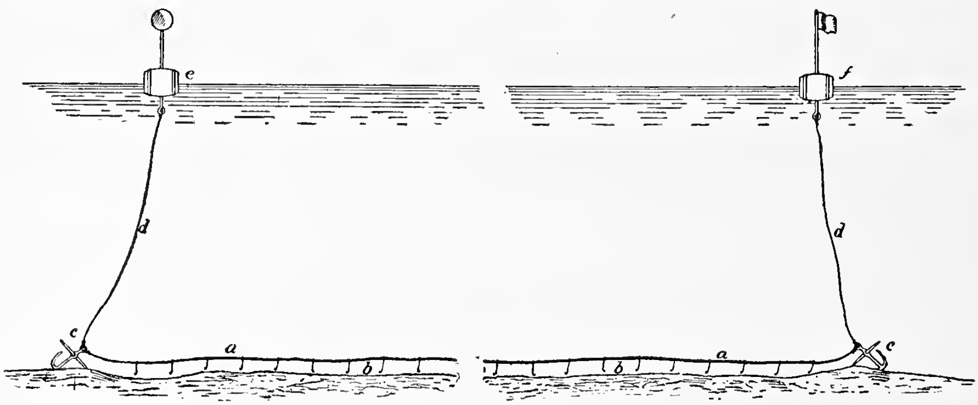
a. Sinker: Lead, weight 5 pounds.
b. Horse: Brass.
c. Hauling line: Tarred cotton.
d. Swivel: Brass.
e. Snood swivel: Brass.
f. Snoods: Tarred cotton.
g. Hook swivel slot.
h. Gangings: Hemp line.
i. Hand reel: Wood.

The following miscellaneous apparatus is used in fishing:

Anchors, Chester patent, net.
Anchors, Chester patent, trawl.
Buoys, halibut trawl.
Buoys, keg.
Compasses, dory.
Fish forks.
Fish pew.
Floats, covered glass—Norwegian.
Gaffs, deck, cod.
Gaffs, dory, cod.
Gaffs, iron, halibut.
Harpoons, assorted.
Hooks, ice.
Hurdy-gurdy, or patent trawl roller.
Jigs, mackerel.
Jigs, squid.
Knives, codfish bait.
Knives, codfish throating.
Knives, dory.
Knives, halibut bait.
Knives, mackerel splitting.
Knives, oyster.
Lance, shark killer.
Lance, whale.
Leads, gill net.
Molds, for sinkers.
Mold, for mackerel jigs.
Nippers, woolen.
Splicers, line, iron.
Swivels, snood.
Swivels, slot.
Slingding spreaders.
Tubs, trawl line.
Whale gun.
Whale gun, bomb lance.

TRAWL LINES.

The *Albatross's* trawl lines are practically the same as those used in the New England fisheries. They have tarred cotton ground-lines, 300 fathoms to the tub, 18 pounds per dozen, and carry 300 No. 14 cod hooks. The buoy ropes are of 9 to 12



CUT 71.—Cod trawl line.

a Ground line; *b* Hooks; *c* Anchors; *d* Buoy ropes; *e* Outer buoy; *f* Inner buoy.

thread tarred manila; keg buoys, with staff and black ball or flag, are used, and the moorings are 16-pound Chester patent anchors.

The gangings are about 3 feet in length, and spaced 6 feet apart on the ground line, to which they are attached by sticking them through a strand and knotting the ends, or by a peculiar hitch known to fishermen, which is quickly made and will not slip. The baited hooks are placed carefully outside of the coil of ground line in the tubs.

Two men are required to set a trawl line from a dory, one pulling as directed, while the other throws the buoy overboard as soon as it is bent to the line, and pays the latter out as fast as he can until he reaches the lower end, when he bends it and the ground line to the anchor, throws it over, and pays out the line, hook by hook, with a peculiar twist of the arm, which throws them clear.

The bottom end of one tub of line is bent to the upper end of the next until the required length is reached, when the ground line and lower end of the buoy rope are bent to the anchor, the latter thrown overboard, the rope paid out, and the buoy bent and thrown into the water. A flag is usually carried on the staff of the inner buoy, and a black ball on the outer one.

Two men are required to haul the trawl; one in the bow heaves the line in over a patent roller fastened to gunwales of dory and worked with a crank, while the other, standing just abaft him, removes fish from the hooks and coils the line in the tubs.

GILL NETS.

The equipment includes a variety of gill nets which may be used as drift nets or anchored either at the surface, at the bottom, or at intermediate depths. They all have floats at the top of the net and sinkers at the bottom, the former having sufficient buoyancy to support the net at the surface. In the event of its being set beneath the surface extra weights are added, and its position at or above the bottom depends upon the length of the anchor ropes.

The following is a list of the gill nets furnished the *Albatross*.

Kinds and dimensions of gill nets.	Length.	Depth.	Size of mesh.	Twine.	Kinds and dimensions of gill nets.	Length.	Depth.	Size of mesh.	Twine.
	Fath.	*Fath.*	*Inches.*			*Fath.*	*Fath.*	*Inches.*	
Trammel net (2)	15	$2\frac{1}{2}$	2	35–3	Shad gill net	50	4	$4\frac{1}{2}$	35–3
			6	12–16	Do	50	4	$4\frac{1}{2}$	35–3
Mackerel gill net	30	$2\frac{1}{2}$	$3\frac{3}{4}$	16–6	Cod gill net	100	2	7	40–10
Do	30	$2\frac{1}{2}$	3	16–6	Do	100	2	8	40–10
Do	30	$2\frac{1}{2}$	$2\frac{1}{2}$	16–6	Herring gill net (2)	20	$2\frac{1}{2}$	$2\frac{3}{4}$	20–6
Menhaden gill net	15	2	$3\frac{1}{2}$	16–6	Do	20	$2\frac{1}{2}$	$2\frac{1}{2}$	20–6
Do	15	2	$2\frac{1}{2}$	16–6	Red-snapper gill net (2)	50	3	9	....

These nets are not all carried at the same time, owing to lack of space. A few of those most commonly used are retained, and others are taken when required.

The following nets are used for surface and shoal-water collecting:

Casting net: Diameter, $5\frac{1}{2}$ feet; mesh, $1\frac{1}{2}$ inches.
Surface tow nets, small: Silk bolting-cloth.
Surface tow nets, large: Netting $\frac{1}{4}$-inch square mesh, twine 20–6, barked, and mosquito net lining.
Wing nets: Cheese-cloth, cotton.
Tub strainer nets: cheese-cloth, cotton.
Dip nets: Silk bolting-cloth.
Dip nets: Cheese-cloth, cotton.
Scoop nets.
Fyke net.

Seines are among the most useful apparatus for collecting alongshore, and the vessel is provided with the Baird collecting seine and the drag seine.

The Baird collecting seine was devised by the late Prof. Spencer F. Baird for the use of naturalists in the collection of specimens along the margins of the sea, lakes, and rivers. It was originally from 9 to 15 feet in length; very light, compact, easily carried by one man and operated by two; but it has since been made in various sizes, and much enlarged, even to 110 feet in length. The three sizes generally used will be described. Stretch measure will be used to indicate the size of mesh.

The Baird seine No. 1 is 15 feet in length and $3\frac{1}{2}$ feet in depth; the middle section of 5 feet, including the bag, 4 feet long, is $\frac{1}{4}$-inch mesh; the wings, each 5 feet in length, are $\frac{3}{8}$-inch mesh. It has ordinary wooden floats and lead sinkers, about 9 ounces to the foot on the middle section, decreasing gradually toward the extremities. A wooden staff on each wing facilitates hauling.

The material of the net is the best quality of cotton seine twine, 20–6 barked.

The Baird seine No. 2 is 25 feet in length and $4\frac{1}{2}$ feet in depth; the middle section of 9 feet, including the bag, 6 feet in length, is $\frac{3}{8}$-inch mesh; the wings are 8 feet long, 4 feet being $\frac{5}{8}$-inch, and the remaining 4 feet at the extremities 1-inch mesh. Twine, floats, sinkers, and staves are the same as those used with No. 1.

The Baird seine No. 3 is 45 feet in length and 6 feet in depth. The middle section of 15 feet, including the bag, 8 feet in length, is $\frac{1}{2}$-inch mesh; the wings are each 15 feet long, the inner half $\frac{5}{8}$-inch mesh, and 1 inch at the extremities. The twine, floats, sinkers, staves, etc., are the same as on the smaller nets.

The drag seine is the largest collecting net used on board the *Albatross*. It is 150 feet in length, 20 feet deep in the bunt, and $2\frac{1}{2}$-inch mesh. It is the ordinary 25-fathom ship seine, fitted in the usual manner.

NAVIGATION: APPARATUS AND METHODS.

The principal implements used in the navigation of the vessel comprise three Negus and one Bliss & Creighton box chronometers, the latter being used as a hack; also a comparing watch. The Ritchie liquid compasses are used for standard, steering, telltale, and boat service. The standard compass has an azimuth circle and alidade, and another is fitted with tripod and circle. A pelorus is provided for taking bearings of objects which can not be seen from the standard. The usual number of sextants and octants are provided; also an artificial horizon.

The Bliss and Walker taffrail logs are used to measure the vessel's speed through the water, and the common hand-lead measures the depths within its capacity, while the Tanner sounding machine, either alone or with the Bassnett atmospheric sounder, or Sir William Thomson's tubes attached, is used in deeper waters. Both telescopic and binocular marine glasses are provided, and for convenience in platting there is a three-arm protractor, a Negus course-indicator, Sigsbee's parallel rulers, drawing instruments, etc.

The chronometers are placed under a lounge in the chart room, the transporting cases being screwed to a false bottom on the deck. In this position they are secure from shocks, and the top of the lounge, opening and shutting on hinges, fits tightly enough to prevent drafts of air or any great changes of temperature. The most powerful disturbing element on the rates of the chronometers has been the vibration of the hull, caused by the dynamo engine, which is usually in operation from dark until 11 p. m. They appear to run equally well together while this vibration takes place every day, and during any material interval that it does not take place at all; but an interruption of either state of repose or vibration is almost invariably accompanied by a change in the record differences in the daily comparison book, showing that their rates are temporarily disturbed.

On reaching port the chronometers are rated as soon as possible by comparison with the time obtained by telegraphic connection with some observatory clock; or, when such connection is not possible, equal altitudes of the sun are taken, and the errors corrected back if the discrepancy is greater than the probable limits of personal and instrumental errors of observation and platting.

The standard compass is placed about 15 feet forward of the smokestack, on the deckhouse, where it was located by a magnetic survey; it was found that in this position the needle was least disturbed by the various magnetic forces exerted by the metal of and in the ship; it is also in a convenient position for use, being handy for taking bearings and under the eye of the officer of the deck when under way.

The standard compass is not compensated, and the local deviation is obtained by swinging ship under steam, observing azimuths of the sun on every point, making a circle with port helm, then with starboard, the mean of the results being accepted as correct. The curve of deviations being platted upon a Napier diagram, a table of magnetic courses is deduced for convenience in laying the ship's head.

The heeling error is obtained by listing the vessel to starboard and port and observing azimuths of the sun as before.

In general terms it may be stated that the changes of deviations due to inclination are such that when heeled to starboard the ship's head is thrown to windward, or toward the higher side, when on any course in the northern semicircle; in the southern

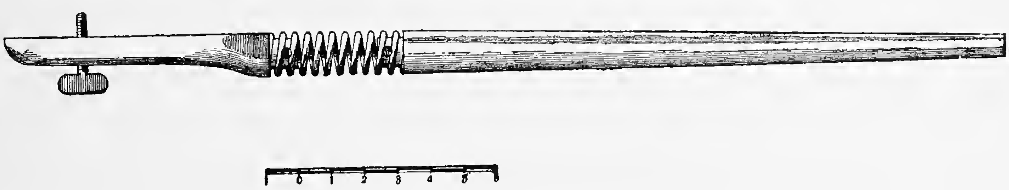
semicircle, when heeled to starboad, the ship's head is thrown to leeward, or toward the lower side.*

When heeled to port the ship's head is thrown to leeward when on any course between southeast and northwest through north, and to windward when on any course to the southward of southeast and northwest. While building, the ship's head pointed N. 29° 30′ W; the ways were in latitude 39° 44′ N., longitude 75° 33′ W.

The sextants and octants are of the ordinary type. One, the lunar sextant, has an attachment called the Tanner flexible staff, its purpose being to eliminate the nervous tremor of the observer or the effect of wind upon the instrument when observing with the artificial horizon.

It is an ordinary wooden staff, 2 feet 6 inches in length, not unlike a walking stick, its upper end flattened on one side and pierced with a $\frac{3}{8}$-inch hole, and a spiral spring of phospher bronze is inserted between the severed parts, 8 inches from the head of the staff, forming a flexible universal joint.

A brass plate with screw thread and thumbscrew is let into the back of the sextant handle, and to mount the apparatus for use it is only necessary to connect staff and handle by means of the thumbscrew.



Cut 72.—The Tanner flexible staff.

A convenient position for observing is to sit on a camp stool, with elbows resting on the knees, and the staff planted firmly on the ground, at an angle that will afford the desired support and enable the observer to change the position of his instrument at will through the flexion of the joint.

The staff should be made of light material, in order to interfere as little as possible with the handling and reading of the sextant.

The taffrail logs, both the Walker and Bliss, are excellent instruments when properly cared for. The former is preferred when running steadily for a considerable time at high speed, while the latter is more convenient for short distances at varying speeds when the fractions of a mile are required, and the necessity for hauling in and putting out is of frequent occurrence, as in sounding and dredging. It is good practice for a vessel engaged in such work to keep one Walker log as a standard, using it for no other purpose, as the propellers of working logs are always liable to injury by coming in contact with the stern of the vessel or being struck by sharks or other fish.

The Bassnett atmospheric sounder used in connection with the Tanner sounding machine for measuring depths within 100 fathoms, without changing the speed of the vessel, is, when used intelligently and properly cared for, a very useful and almost indispensable adjunct for coasting at night or in foggy weather.

It operates on the principle of the compression of a column of air proportioned to the increase of pressure as it sinks beneath the surface. It is composed of a glass

* She has recently been supplied with compensating binnacles.

tube inclosed within a shield of brass, in which appropriate slits expose portions of the tube longitudinally. The upper end of the tube is air and water tight, and at the lower end is a valve which turned in one direction admits water and prevents its escape; thus the top of the column of water indicates the depth in fathoms, read from a scale attached to the body of the sounder. A reverse movement of the valve allows the water to escape, and it is only necessary to replace it in its former position to prepare the apparatus for another cast.

The action of the sounder depends upon the valve being tight and this is assured only by constant and intelligent care. It should be rinsed in fresh water, dried and oiled after using, and requires frequent examination and adjustment to guard against oxidation, and to see that the valve can be moved by hand, while it is sufficiently tight to prevent leakage.

Sir William Thomson's tubes have their interior surfaces coated with a chemical preparation that becomes discolored upon contact with sea water, and the compression of the column of air or the penetration of the column of water is measured on the tube by a scale showing fathoms of depth. It works on the same principle as the Bassnett tube, and is sometimes preferred because it has no valve to be cared for. The disadvantage is that the number of soundings are limited to the supply of tubes, which can not always be renewed when most needed.

No vessel should be considered seaworthy unless she carries some reliable apparatus for ascertaining the depth to 50 fathoms at least without slackening her speed.

The Rogers portable micrometer telescope is a very reliable and useful instrument. A description and method of using it is to be found in the revised edition of Bowditch's Navigator, page 177. A modification of that method was adopted on board the *Albatross*, which required less computation and avoided the necessity of picking out each time the log. cotangent of such a small angle. Lieutenant Schroeder describes it as follows:

The greatest angle this instrument can measure is 1,750 micrometer divisions, or about 1° 45′, and it is seldom that an angle of over one-half or three-quarters of that is observed with it. In such small angles the functions may be considered as proportional to the arcs, that is, the cotangent of the angle measured is equal to the cotangent of one micrometer division divided by the number of those divisions. The log. cotangent of one division being accurately determined once for all, the rule for finding the distance is simply to add that function to the logarithm of the height, and from the sum subtract the logarithm of the number of divisions.

Example: A light-house 200 feet high is found to subtend an angle of 1,700 micrometer divisions. The value of one division of the instrument on board the *Albatross* is 3″.655, of which the log. cotangent is 4.7515377, or in practice 4.75154.

SHORT METHOD.

200 feet	log. 2.30103
1 M. D	log. cot. 4.75154
	7.05257
1.700 M. D	log. 3.23045
6,639.3 feet	log. 3.82212

RIGOROUS METHOD.

3.″655 × 1.700 = 6.213″.5 = 1° 43′ 33″.5.

200 feet	log. 2.30103
1° 43′ 33″.5	log. cot. 1.52097
6,637.4 feet	log. 3.82200

The smaller the angle, the smaller of course will be the discrepancy.

For rapid work in a hydrographic survey or reconnaissance, 10 feet is found to be a convenient length of staff to handle, and the logarithm of 10 being 1.00000 makes the computation all the easier. A board 10 inches broad, painted white, with a 2-inch black stripe down the middle, will be found to be an easily distinguished target.

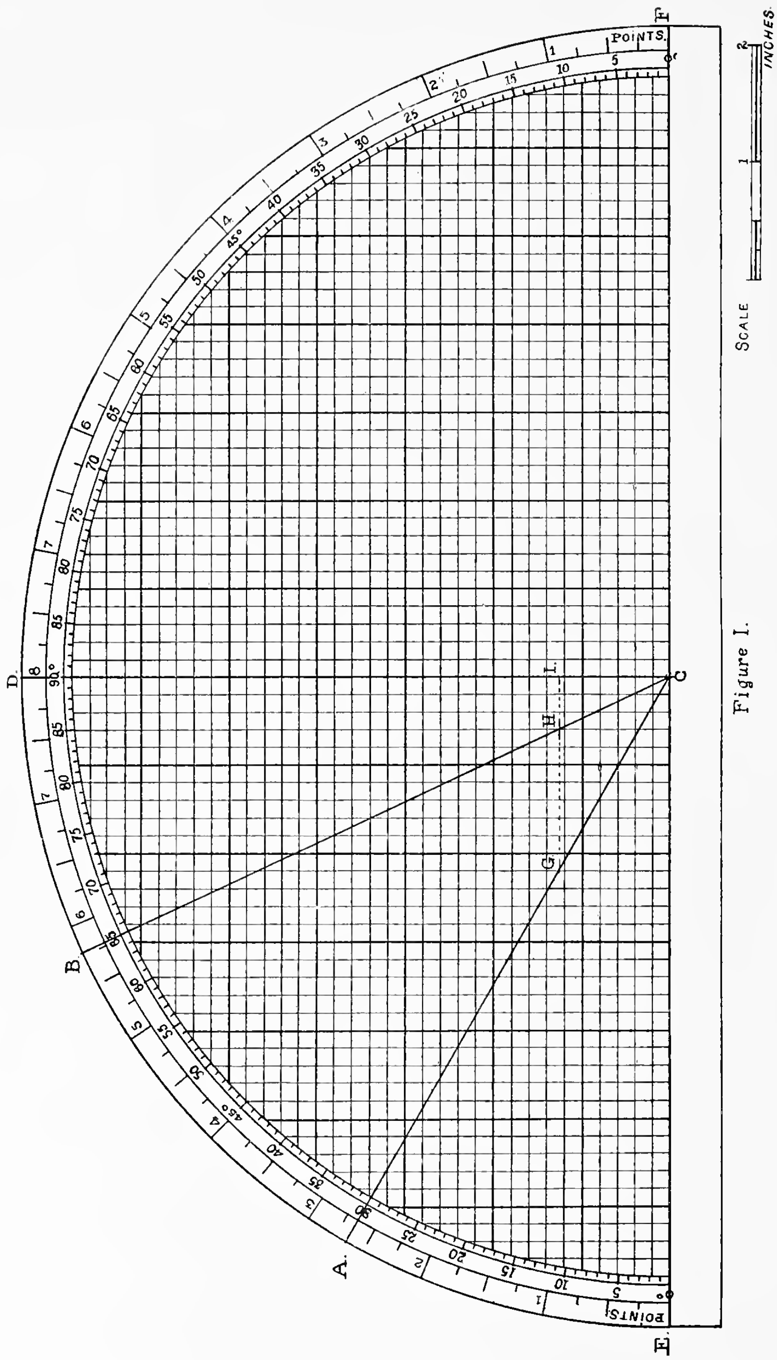


Figure I.

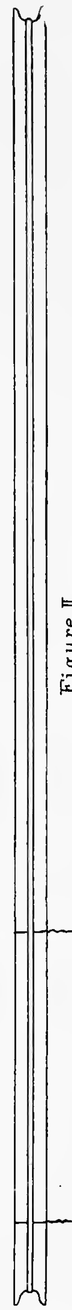


Figure II.

THE BLISH DISTANCE FINDER.

THE BLISH DISTANCE-FINDER.

This is a simple and admirable little instrument devised by Lieut. John B. Blish, United States Navy, and used on board the *Albatross* for several years, where it was found particularly valuable when coasting at night or during stormy weather.

With the course and distance, and two bearings of a point of land, without computation or reference to books or charts, the distance-finder will give the distance of the point at the time of the first and second bearings, the distance to be run from the second bearing to bring it abeam; also the distance at which it will be passed if the course is maintained. Repeated observations will show whether the vessel is actually making her course.

The distance-finder, as improvised and used on board the *Albatross*, is shown in plate XXXVIII; fig. I is a plan, and fig. II a sectional view. Scales of degrees and points are marked on the arc; C D, C E, and C F are scales of equal parts, which may be used as miles or fractions of a mile. A and B are silk threads pivoted at C and drawn under an elastic band which rests snugly in a groove surrounding the instrument, as shown in fig. II. The elastic band permits free movement of the threads of silk, yet holds them in place when set. The vessel is supposed to be heading at all times from C to E, hence all bearings are plotted in points or degrees from E.

To use the distance-finder, take a bearing of a point, note the number of degrees or points it bears from the ship's head, set the arm A, counting the degrees from E, and note the reading of the log; steer the same course until the bearing of the point has changed sufficiently to make a practicable angle, then take a second bearing, and set the arm B on the number of degrees or points the object bears from the ship's head, counting from E as before; also note the distance run between the first and second bearings. With the distance by log, taken from the scale of equal parts C E or C D on a pair of dividers, find G H between the arms A B parallel with C E. Then G will be the position of the ship when the first bearing was taken, and H when the second bearing was taken; the interval C G is the distance of the vessel from the point when the first bearing was taken, C H the distance from the point when the second bearing was taken, H I the distance to be run to bring the point abeam, and C I the distance at which the vessel will pass the point.

If the vessel is to pass within 5 miles of the point, it will be found convenient to have the divisions on the scale of equal parts represent half miles instead of miles. In reading the scale fractions are estimated in tenths to correspond with the divisions of the patent log.

EXAMPLE:

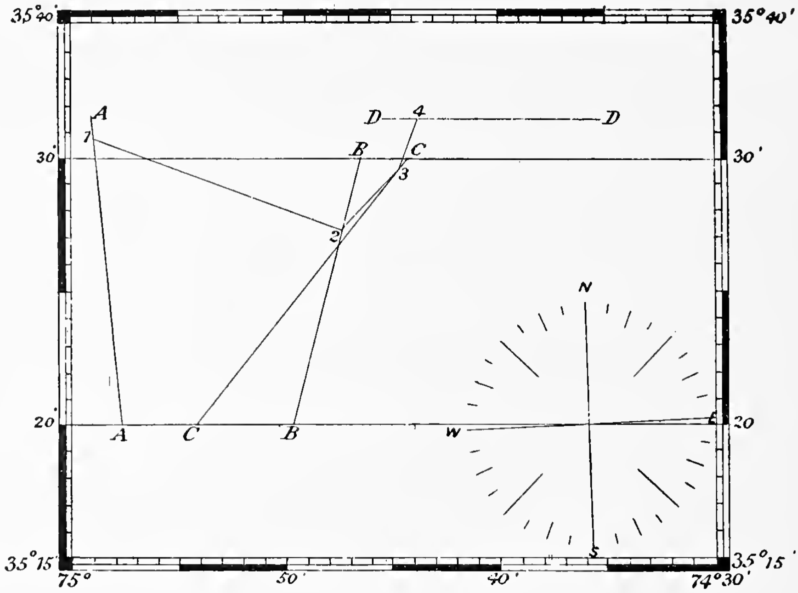
First bearing 30° from ship's head (or E).
Second bearing 65° from ship's head (or E).
Distance by log between first and second bearings, 8 miles.
Set the arm A on 30° for the first bearing, and the arm B on 65° for the second bearing.
Thus 8 miles, the distance run by log, equals G H.
C G, measured on scale of equal parts, equals 12.6 miles, the distance of point at first bearing.
C H equals 7 miles, the distance of the point at the second bearing.
H I equals 3 miles, the distance to be run from the second bearing to bring the point abeam.
C I equals 6.3 miles, the distance the point will be from the vessel when it is abeam.

The intervals C I and H I are most used in practice, but should C G and C H be required, they may be measured on the scale with dividers, or by grasping the arm A at G, or the arm B at H, and carrying them to the scale. The distance-finder in use on

board the *Albatross* was improvised by Ensign Henry B. Wilson, United States Navy. The scales were marked with india ink on Irish linen writing paper, which was then glued to a wooden back, and finally given several coats of shellac varnish to protect it from moisture. Sewing silk was used for the arms, which were held in place by an ordinary elastic band fitting closely in the groove, and a small round nail was used for a pivot from which they worked. The left quadrant of the semicircle is used in the description and example; the right one may be used in like manner by assuming that the ship's head is in the direction of F instead of E.

The instrument is used as though the vessel was always on the line C E, steering toward E, but in reality she was at G when the first bearing was taken and at H at the time of the second bearing, steering toward I on the line G H I, the pivot C being the point on which both bearings were taken.

The distance-finder is constructed on the principle of Table 5 A, Bowditch Navigator.



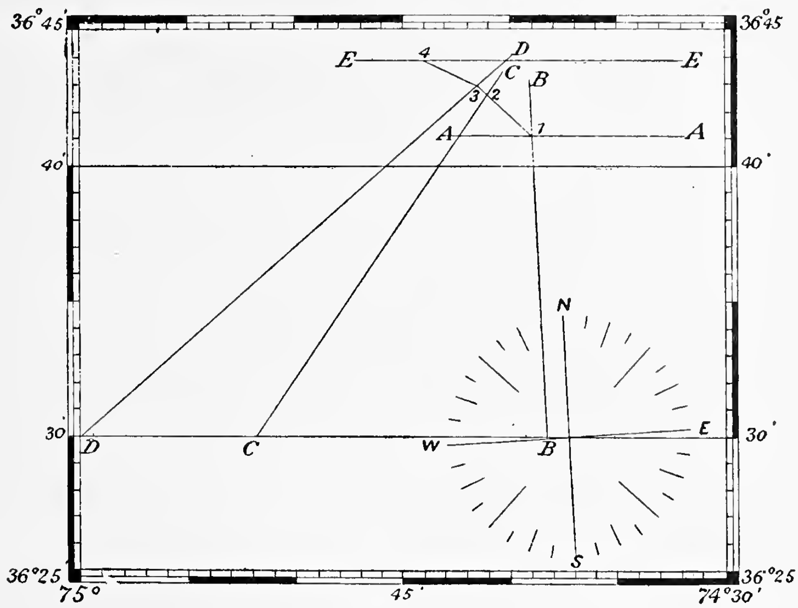
Cut 73.—Case I.

SUMNER'S METHOD.

In the navigation of the *Albatross*, and the location of dredging, sounding, and other stations, Sumner's method of finding the position at sea is used *in extenso*. All positions, however determined, are plotted as lines, and not points—the intersection of two such lines, corrected for the intervening run and current, defining the exact position. The lines of position consist of portions of circles of equal altitude of the sun, moon, stars, and planets; parallels of latitude deduced from meridian or ex-meridian altitudes of the same bodies; lines of bearings of headlands or well-known objects on shore; circles of equal distance from known objects, found by micrometer or by their dipping below the horizon. Computations are made from forms and examples to be found in Bowditch's Navigator.

Case I.—On April 28, 1883, single altitudes of the sun were observed at 6.43 a. m., 8.47 a. m., and 10.23 a. m., a sounding being taken at the time of each sight. The meridian altitude was observed at noon. The three time-sights were worked out for latitudes 35° 20′ N. and 35° 30′ N., placing the vessel respectively on the lines A A, B B, C C; and the meridian altitude placed her in latitude 35° 31′ 35″, D D. From the first sounding, ran 10 miles ESE. (mag.) to the second, where the temperature of the surface water and the current showed that the edge of the Gulf Stream had been reached. From the second to the third the drift in trawling and current was estimated at 3 knots NE. From the end of the third east to noon the drift and current were about 2 miles NNE. These being plotted, place the ship in the positions 1, 2, 3, 4.

Case II.—While sounding at about 7 a. m., May 1, a meridian altitude of the moon was observed, showing the latitude to be 36° 41′ 05″ N. At the same time a single

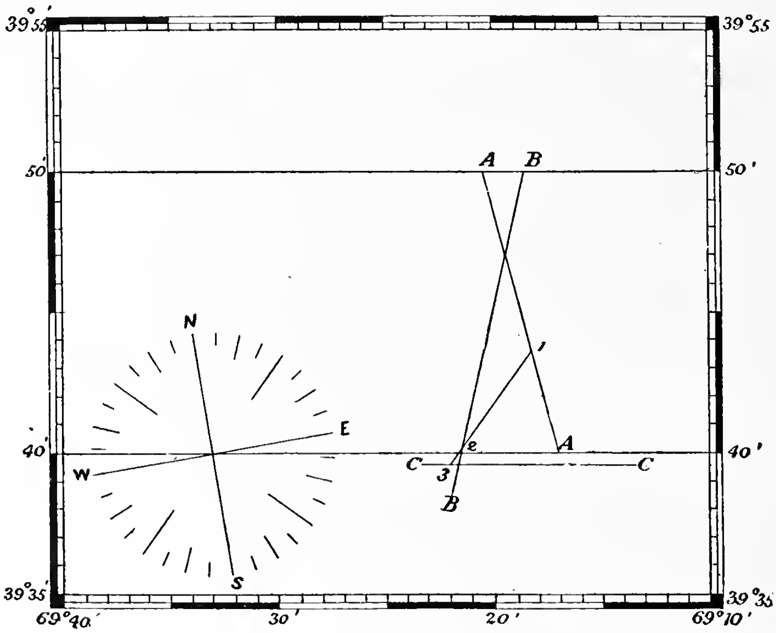


Cut 74.—Case II.

altitude of the sun was observed and worked out for latitudes 36° 30′ and 36° 40′. The ship was therefore at the intersection of the two lines thus found, A A, B B. While trawling, two more sights of the sun were taken, at 10.09 and 10.49; and being worked out with the same latitudes as before, placed the ship on the lines C C, D D. Finally a meridian altitude of the sun was observed, which placed the ship in latitude 36° 43′ 54″ at noon, E E. The drift while trawling, until the last time sight, was to NW., 2½ to 3 knots in all; and then, after the sight NW. by W. ½ W., 2¼ miles to noon. No current noticeable. Plotting the track, the ship was found to have been in the positions 1, 2, 3, 4.

Case III.—At 3 and 5.45 p. m., August 1, single altitudes of the sun were observed and worked out for latitudes 39° 40′ N. and 39° 50′, giving lines A A and B B. At about 7.30 an altitude near meridian of * Antares was taken, which placed the ship at that time on the parallel of 39° 39′ 23″, line C C. The drift in trawling during the afternoon

was SW., and the distance estimated at 4 knots between the first and second sights and $\frac{3}{4}$ to 1 knot from the second to the third. Plotting the track the ship was found to have been in positions 1, 2, 3. No current observed.

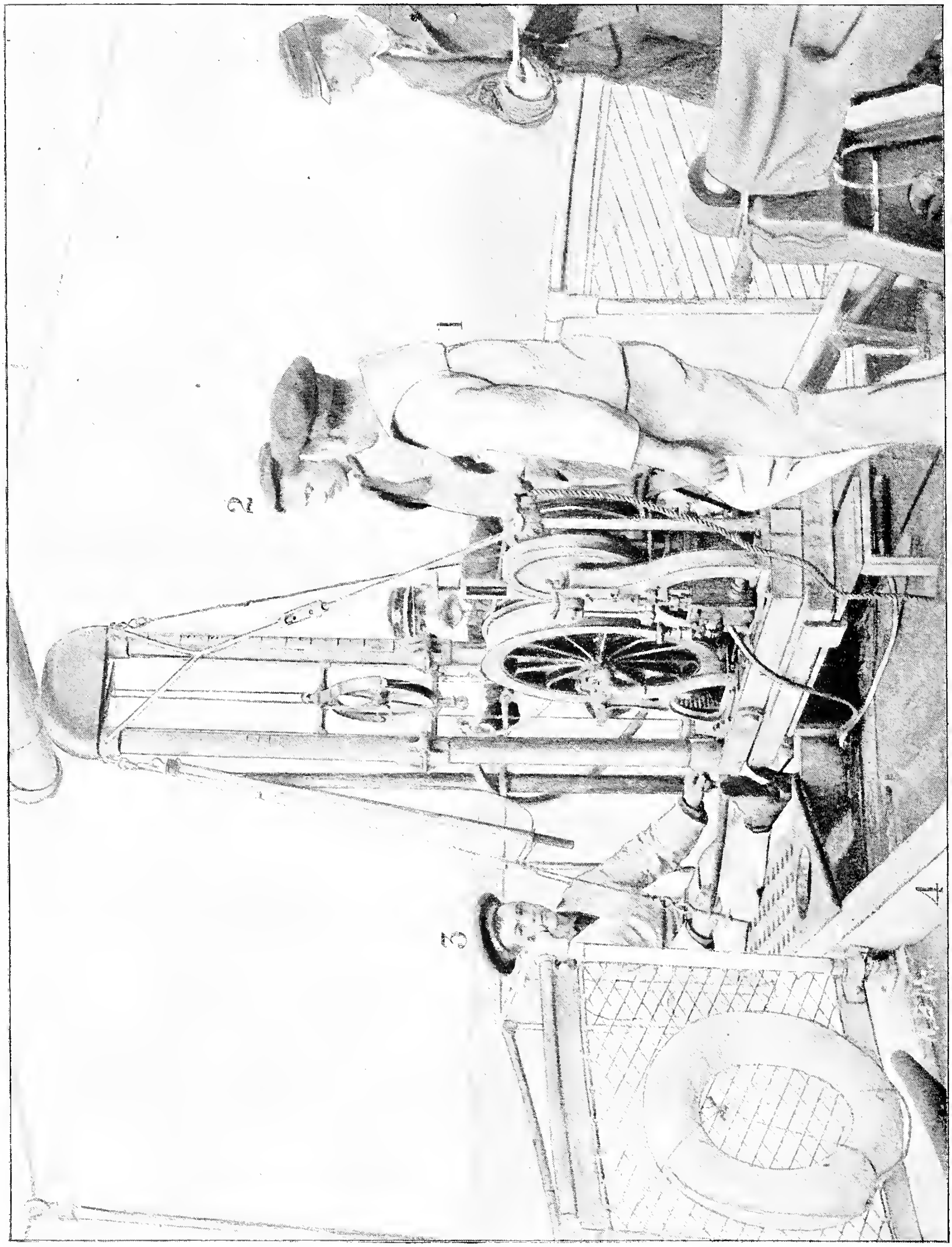


Cut 75.—Case III.

OTHER METHODS.

In addition to the above-mentioned methods, advantage is taken whenever possible of the simple "four-point problem" of finding the distance from an object by reading the taffrail log when it bears exactly four points off the bow, and again when it bears exactly abeam, the distance from the object at the second bearing being equal to the distance run between the two, plus or minus the current.

At each sounding the current is carefully estimated by noting the direction and speed of the ship necessary to keep the sounding-wire vertical after the sinker has passed below the surface drift. A fair guide is thus afforded as to what allowance should be made in shaping the course to the next position, as well as in correcting the run up to that point. Such help is particularly desirable when clouds by day or night prevent taking frequent observations.



STATIONS AT THE SIGSBEE SOUNDING MACHINE—WIRE GOING DOWN.

THE CONDUCT OF DEEP-SEA EXPLORATION.

The economical use of material and forces at the disposal of the commander in the conduct of extended deep-sea exploration assumes greater importance than is usual in ordinary operations either on land or sea.

The relation of speed to the fuel supply and the amount of work to be accomplished will be among the first considerations, and after he has decided upon the daily coal consumption the best results will be obtained by—

1. Carrying sail whenever the wind serves.
2. Keeping the chief engineer informed regarding the service to be required of the engines, and giving due warning to the engineer of the watch when approaching a station, and the probable detention.
3. Having due regard to the fact that the *Albatross* has twin screws, capable of working independently or together, and that one engine will frequently perform the duty as well or better than both when, as in sounding with light winds, it is desired to hold the vessel in position without gaining headway or sternboard, or if very low speed is required, as in operating the trawl or dredge.
4. Using one engine only, whenever it will answer the purpose, will reduce the wear and tear and lighten the duties of the engineer of the watch, which are sufficiently trying at best when the vessel is engaged in sounding or dredging.

The operations included in the full occupation of a station follow in their natural sequence:

1. Sounding, including surface and bottom temperatures and water specimens.
2. Serial temperatures and specific gravities.
3. A haul of the trawl.
4. A haul of the dredge.
5. A haul of the tangles.
6. Surface and intermediate collecting.
7. The use of trial lines.
8. Setting trawl lines.
9. Setting gill nets.
10. Current observations.

SOUNDING.

Soundings are made under the direct supervision of the officer of the deck, who is responsible for the prompt and systematic execution of the necessary evolutions and accuracy of measurements. He should, before reaching a station, satisfy himself by personal examination upon the following points:

1. That the crew of the sounding machine are at hand, and that each man understands his duties, also the duties of every other member of the crew.
2. That there are no slack turns of wire on the reel, or, should he discover any, have them run off on a spare reel and properly rewound. Slack turns will never occur with a properly drilled crew except the reel collapses, a rare occurrence with the Navy reel.
3. That the stray line and its splice are in good condition. Should a defect be discovered too late to renew the splice without delaying operations, substitute a Tanner link, which can be attached to the wire in a moment and will answer the purpose until such time as a new stray line can be spliced on.
4. That the belt is sound and in good working order, and that there is a spare one on the machine. If in doubt as to the reliability of the old one, cut it away and bring the spare one into use.
5. That the register is set at zero when the sinker is at the water's edge; the pointers securely fixed to their stems; that the spur wheel meshes properly in the worm wheel, and that all of its gearing works freely.
6. That the friction rope is in place and in good condition, and that the auxiliary brake is in working order.

7. That the Sigsbee sounding rod is in good order generally, swivel and tumbler working freely, and the spring in the latter properly adjusted. That the two parts of the cylinder are screwed together tightly, the valve properly seated, and its spring in action.

8. That there is a supply of bailed sinkers in the racks near the sounding machine, and that the sounding rod will pass through them freely.

9. That all moving parts of the machine, including the reeling engine, are properly oiled and cared for.

10. That the deep-sea thermometer used for bottom temperature is in good order; that the column breaks promptly, propeller moves freely; that the instrument is properly cushioned by the rubber gaskets and spiral springs which suspend it in its case, and that the clamp is in working order. The Negretti & Zambra deep-sea thermometers are used on board the *Albatross*, and being delicate ments they should be carefully treated in order to obtain the best results. They should be habitually carried bulb down, with columns connected, and it is a good plan to keep them in a bucket of water between stations, as it insures their safety and keeps them at a temperature approximating to that of the surface water.

11. That the Sigsbee water specimen cup is in good working order generally; and, if it is intended to bring up a water specimen at the next station, that the interior of cup is clean and free from foreign substances, valves adjusted, propeller and sleeve working freely, and the clamp in good condition.

12. That a quart or more of sperm oil in a suitable vessel is secured to the frame of the sounding machine forward of the reel with sponge, waste, or other material for oiling the wire.

13. That the wire clamp and guide are in their respective places.

14. That the portable incandescent lights are led out and hung in place if the next station is to be occupied at night.

The engineer of the watch should be warned half an hour at least before reaching the station, and again five minutes before making the signal to stop the engines. The necessary preparations should then be made on deck and the sounding crew sent to their machine. Arriving at her station with calm weather and smooth sea, the vessel is stopped without changing her course, but if it is blowing and a sea running she would be turned stern to by putting the helm up, slowing down, and backing the lee engine until the wind is on the quarter, then backing both until the vessel loses headway, taking care not to get a sternboard. Once in position, it can usually be maintained by slowly backing the lee engine.

If sounding in considerable and approximately known depths, it is not necessary to wait until the vessel is at a stand stern to sea; the sinker may be started down as soon as the wind is on the quarter and the wire brought up and down during its descent. The *Albatross* frequently gained from 100 to 200 fathoms in this manner.

The crew of the Sigsbee sounding machine is composed of three seamen and a fireman, numbered 1, 2, 3, and 4; the officer of the deck and a recorder. Their stations and duties are as follows:

PREPARING TO SOUND WITH THE SIGSBEE MACHINE.

When ordered to man the sounding machine (plate XXXIX), No. 3 bends the stray line to the sounding rod, No. 4 places the sinker in the mounting rack on the left of the machine forward of the grating, the former then hooks the bail over the tumbler of the rod, lifts the shot from the rack, and swings it to the after end of the machine, when No. 2, who has shipped the right crank, heaves in the slack line until the sinker is suspended beneath the swivel pulley, where it is held by engaging the pawl on the ratchet wheel.

No. 1 wipes the V groove on the reel, and when dry and free from oil adjusts the friction rope and attends it.

STATIONS AT THE SIGSBEE SOUNDING MACHINE—WIRE COMING UP.

STATIONS—WIRE GOING DOWN.

The officer of the deck having taken his station on the grating to the right and abaft the machine, directs the sinker to be lowered a fathom below the surface of the water, the auxiliary lead bent to the stray line, the thermometer clamped a fathom above it, and the water-specimen cup a fathom above the latter, having first satisfied himself that the instruments are in perfect order. When everything is in readiness he directs the pawl to be thrown back, the crank unshipped, and gives the order to lower away.

No. 1, standing forward of the machine and facing it, attends the friction rope and makes the sounding as quickly as possible, having due regard for the safety of the apparatus. As soon as the sinker reaches bottom, and No. 2 has shipped his crank, No. 1 throws off the friction rope, ships the left crank, and assists in heaving the specimen cup clear of the bottom.

No. 2, on the right of the machine and facing it, attends the auxiliary brake in case of accident to the friction rope, or if the reel becomes unmanageable from any cause. As soon as the sinker strikes the bottom he ships the crank, heaves in a few fathoms of wire, and, when it is ascertained that the sinker is detached, he unships the crank, adjusts the dynamometer staff under the accumulator pulley, and assists in putting on the belt.

No. 3, seated on the grating to the left and abaft the machine, attends the swivel pulley, and, if the wire is accidentally slackened by the sinker unexpectedly striking bottom, grasps the bight and pulls it aft, taking up a fathom or more, which is often sufficient to prevent kinking or flying off the reel. When the sinker is down, he feels the wire to see whether it is detached, then assists No. 2 in adjusting the dynamometer staff.

No. 4 stands forward and to the left of the machine until he wishes to prepare the engine for reeling in, when he moves about it, as occasion requires, keeping out of the way of No. 1.

In case the sinker fails to detach, the officer or No. 3 pulls the bight of the wire aft from the machine, then lets it go, repeating the operation several times if necessary; and, if it still fails to detach, Nos. 1 and 2 ship the cranks and heave the sinker clear of the bottom, then carefully land it again, when the manipulation of the wire is repeated.

The sinker should not be landed on the bottom abruptly when trying to detach it, for, as a rule, the trouble results from its having sunk deeply into the soft ooze.

STATIONS—WIRE COMING UP.

No. 1 stands on the left of the machine abreast of the reel (plate XL), and, with sponge or rag, oils the wire as it comes in. When the stray line is sighted, and the reeling engine stopped, he throws the pawl into action, ships the crank, and assists in reeling it in by hand.

No. 2, standing on the right of the machine, guides the wire smoothly on the reel, reports defective splices, nips, or kinks, and attends the auxiliary brake in case of accident to the belt. When the stray line is sighted he ships the crank and heaves it in by hand; then assists No. 4 to remove the belt from the reel.

No. 3, standing or sitting on the grating to the left and abaft the machine, attends the swivel pulley leading the wire fairly into its score. He warns No. 4 to stop the reeling engine if he discovers anything unusual or suspicious on the wire as it is

coming in, also when he sights the stray line. He unclamps the water-specimen cup and thermometer, unbends the auxiliary lead, hitches the end of the stray line to the fair-leader, and unships the dynamometer staff. He also delivers the bottom specimen to a naturalist in the laboratory, washes the specimen cup, and returns it to its place near the sounding machine.

No. 4, stationed forward of machine, adjusts the belt, attends the belt-tightener, and runs the reeling engine. Fixing his eye upon the dynamometer scale, he reels the wire in as rapidly as possible, keeping within the prescribed tension; and it requires a dexterous manipulation of the throttle to regulate the speed according to the rapidly varying strains. He reduces the speed of the reeling engine at 200 turns, and again at 100, to avoid jumping the thermometer and specimen cup out of the water, and, stopping when the stray line is sighted, he loosens the belt-tightener, throws off the belt, wipes up the oil about the engine, and prepares it for the next cast.

The crew examine the stray line and its splice, the surface wire on the reel, and all parts of the sounding machine, which they wipe carefully; the bearings are oiled, deck around the machine cleaned up, and everything put in place.

STATION AND DUTIES OF THE RECORDER.

He takes his place at the right of the machine where he can best observe the readings of the register. He keeps a record of everything connected with the sounding, filling the blanks in the record book, and making such further entries as the occasion requires. Having assured himself that the recording watch agrees with the ship's clock, he will note:

1. The date, day of the month, and year.
2. The serial number of the sounding.
3. The machine to be used, Sigsbee or Tanner.
4. The reel used, Sigsbee, Navy, or Tanner.
5. The kind of sinker used: A deep-sea lead, giving its weight; a 35-pound or 60-pound shot.
6. Reading of the patent log, when it is hauled in after the vessel stops to sound.
7. Hour, minute, and second, the sinker starts down.
8. The minutes and seconds for each 100 turns of wire, as shown by the register.
9. The exact time the sinker strikes bottom.
10. The number of turns of wire out when the sinker reaches bottom.
11. Correction to be added to the number of turns to get the depth in fathoms.
12. Depth in fathoms.
13. Time of starting to reel in the wire.
14. If the patent log is put over, note the time and read it when vessel reaches her course.
15. Time for each 100 turns of wire coming in.
16. Time wire is all in.
17. Reading of deep-sea thermometer.
18. Maker's number of thermometer.
19. Thermometer correction.
20. Corrected temperature.
21. Reading of patent log when last turn of wire came in.
22. Character of bottom.
23. Note if water specimen was taken.
24. Any unusual occurrence, such as fouling, kinking, running off the reel, or parting the wire; slack turns; loss of the stray line; delay in detaching the sinker; injury to or loss of instruments; discovery of imperfect splices, or detention from any cause.

The speed of deep-sea sounding varies with the meteorological conditions, character of vessel, apparatus, personnel, and the purpose for which the soundings are required. Time will be gained if the deep-sea thermometer can be dispensed with, and a greater gain will follow by using a cup of less weight and cross-section where a small bottom specimen will suffice.

Table I is taken from the original record of sounding No. 424, Hawaiian cable survey, December 18, 1891, and shows the rate of descent and ascent of the wire for each 100 turns of the reel and must not be mistaken for fathoms. The time intervals were kept with the greatest care as a matter of record, not for the guidance or

instruction of the operator at the friction rope, who was an expert and at liberty to take advantage of every favorable circumstance to accelerate the descent of the sinker. The conditions of wind and sea, while not perfect, were favorable for rapid work. A moderate northeast trade and small sea were accompanied by an occasional long, rolling swell from a recent gale.

A careful analysis of Table I shows:

1. That the time intervals were not seriously affected by wind or sea.

2. That the friction increased steadily with the length of wire out, retarding the descent of the sinker proportionately.

3. That the operator felt the sounding shot at intervals by slightly increasing the friction until satisfied that there was no slack wire between the reel and sinker.

4. That he maintained the friction approximately equal to the weight of submerged wire, as the reel stopped promptly when bottom was reached. We know this because it required but 2 minutes and 5 seconds to ship the cranks and heave the specimen cup clear of the bottom, adjust the belt, and commence reeling in.

5. That the prescribed limit of 120 pounds tension was closely followed while reeling in. The friction is observed to diminish as the wire comes up, but not with the regularity of the increase during its descent, for the following reason:

6. The sounding was made with stern to wind and sea, and the wire maintained in a vertical position without headway or stern board; but, as soon as the sinker reached bottom, the vessel began to turn, with one propeller moving slowly, her way through the water being slight for a couple of minutes, then gradually increasing until at 5 minutes she was on her course, dragging the wire transversely through the water 2 or 3 minutes until it trailed out astern, and from that time the friction decreased regularly until the 200 mark was reached, when the speed of the reeling engine was checked; again at 100 turns it was slowed still more to prevent the sounding cup, thermometer, etc., from jumping out of water, for by this time the vessel was steaming at the rate of 7 or 8 knots.

The patent log was put over at the 2,000 mark, and during the 14 minutes consumed in reeling in the remaining wire the vessel steamed 1.4 knots on her course.

TABLE I.

Sounding wire.		
Going down.	No. of turns.	Coming up.
M. S.		*M. S.*
....	....	0 50
0 45	100	0 40
0 50	200	0 35
0 50	300	0 35
0 50	400	0 40
0 55	500	0 40
1 05	600	0 45
1 00	700	0 45
1 00	800	0 45
1 05	900	0 50
1 05	1,000	0 50
1 10	1,100	0 55
1 10	1,200	0 55
1 10	1,300	1 00
1 15	1,400	1 00
1 15	1,500	0 55
1 20	1,600	1 05
1 20	1,700	1 05
1 25	1,800	1 05
1 20	1,900	1 10
1 25	2,000	1 10
1 35	2,100	1 20
1 30	2,200	1 20
1 30	2,300	1 15
1 30	2,400	1 15
1 40	2,500	1 10
1 40	2,600	0 40
1 00	2,661	....

Table II is compiled from the original records of six soundings, including No. 424, from which Table I was taken, and is intended to illustrate the mean speed and uniformity of the *Albatross'* soundings under normal conditions.

TABLE II.

Serial No.	Date.	Depth.	Fathoms per minute going down.	Time required to put on belt and start reeling in.	Fathoms per minute coming up.	Total detention for each fathom of depth.	Total time consumed in making the sounding.
		Fathoms.		*h. m. s.*		*h. m. s.*	*h. m. s.*
386	Dec. 14, 1891	2,696	85.6	0 1 45	112.3	0 0 1.27	0 57 15
392	Dec. 15, 1891	3,006	83.5	0 2 25	106.4	0 0 1.33	1 06 40
395	do	3,030	75.7	0 2 00	92.5	0 0 1.49	1 15 00
401	Dec. 16, 1891	2,916	83.7	0 1 50	109	0 0 1.34	1 03 25
405	Dec. 17, 1891	3,034	83.8	0 3 20	82.3	0 0 1.51	1 16 20
424	Dec. 18, 1891	2,825	86.2	0 2 05	112.2	0 0 1.27	1 00 00
Mean		2,918	83.1	0 2 14	102.45	0 0 1.37	1 06 27

TAKING SERIAL TEMPERATURES.

In order to guard against the loss of instruments, a large and strong temperature wire is used. It is steel piano wire, No. 21 music, about 0.045 inch in diameter, or No. 17 American gauge; it is in a single length of 1,225 fathoms, wound on a Sigsbee reel, and kept in a reel box in readiness for use.

Serial temperatures when taken always follow a sounding, and if water specimens are required for specific gravities a specimen cup is clamped to the wire a fathom above each thermometer. An assistant examines the thermometers and water-specimen cups in the laboratory and places them in buckets or other convenient receptacles in readiness to be carried to the sounding machine.

Preparatory.—When the sounding is completed, No. 1 guides the stray line on the reel and secures the end to its own part, removes the left cap-square and assists in dismounting the sounding reel and mounting the temperature reel; then replaces the cap-square, secures the roller guide in place, runs the end of the stray line over the accumulator pulley and through the guide, and adjusts the friction rope.

No. 2 reels in the stray line, unships the crank, removes the register and right cap-square; assists in dismounting the sounding reel and mounting the temperature reel; then replaces the cap-square and register, assists in securing the roller guide and in reeving the end of the stray line. He ships the crank and lowers the sinker a fathom below the surface when ordered.

No. 3 brings the deep-sea thermometers and water-specimen cups, assists in shifting the reels and in removing the fair-leader and swivel pulley. He bends a deep-sea lead to the stray line for a sinker and suspends it by the pawl below the roller guide, where it hangs quietly until it is lowered beneath the surface preparatory to clamping on the first thermometer.

No. 4 removes the fair-leader and swivel pulley and assists in shifting the reels and replacing the cap-squares. A convenient method of mounting or dismounting a reel is to use a small watch tackle from the main boom. If the boom is not available, lash a handspike across the reel in line with its shaft and four men will readily lift it out of its bearings or replace it, as the case may be.

STATIONS—INSTRUMENTS GOING DOWN.

No. 1 attends the friction rope (plate XXXIX), following the same general rule as in sounding. He is given the stopping-places in succession, and should bring the wire to a stand without jarring the instruments or bringing unnecessary strain on the wire itself. When the last thermometer has been lowered to its place and the pawl brought into action, he removes the friction rope from the groove and prepares to oil the wire as it comes in.

No. 2 passes the thermometers to the recorder, who notes their numbers, then to the officer in charge. The water-specimen cups are passed directly to the officer. He then stands in readiness to use the auxiliary brake.

No. 3 receives the thermometers and water-specimen cups from the officer and clamps them to the wire, as directed in sounding. When the last thermometer has been lowered to its place, he brings the pawl into action. An interval of five minutes is allowed for the last instrument of the series to take the temperature.

No. 4 puts belt on, gets reeling engine in readiness, and ships ratchet crank on driving shaft, where it is allowed to remain to assist in bringing the instruments carefully to the point above the grating, where they are removed from the wire.

STATIONS—INSTRUMENTS COMING UP.

No. 1 oils the temperature wire as it is wound on reel (plate XL), and passes water-specimen cups to an assistant in the scientific department, who turns their contents into specially prepared bottles.

No. 2 guides the wire fairly on the reel, receives the thermometers from the officer in charge, holds them in position for the recorder to verify the reading, then engages the propeller spindle and places them, bulb down, in a bucket or other secure place.

No. 3 seats himself on the grating, watches the wire and reports the appearance of instruments at the surface, also when they are in position to be conveniently removed. He unclamps the water-specimen cups and thermometers, passing the former to No. 1 and the latter to the officer in charge. He reports if instruments fail to act through the fault of their mechanism, and when they are all in he unbends the sinker.

No. 4 attends the throttle and reels the wire in, starting and stopping carefully at the designated points to avoid jarring the thermometers. He watches the register for the designated number at which he is to stop, giving heed also to the warning of No. 3 that the instruments have reached the surface.

The officer in charge directs when the sinker is to be lowered into the water and the first thermometer clamped to the wire, for, unlike deep-sea sounding, it should not be lowered until the vessel is in position and at a stand.

He examines thermometers and water-specimen cups, as directed in sounding, and passes them to No. 3, observing that he does not fail to catch the bight of the wire over the clamp screw to prevent slipping. This is quickly done by first engaging the upper jaw and throwing the frame forward until the wire slips easily over the screw head, then bringing it back into position and engaging the lower jaw.

He receives the thermometers from No. 3 as he unclamps them from the wire, carefully reads the temperature with a reading lens, and passes them to No. 2, who holds them before the recorder's eye while he verifies the reading to degrees without the use of a lens.

It has been found in practice that the officer may occasionally make a mistake in the degrees when using the lens, but not in the decimals of a degree, to which he naturally gives the greatest consideration, while the recorder, observing without the lens, quite as naturally gives his first attention to degrees.

DUTIES OF THE RECORDER.

In observing serial temperatures the recorder takes his station at the right of the machine and—

1. Sees that the register is set at zero when the instruments first attached are at the water's edge.
2. He informs the operator at the friction rope where each thermometer of the series is to be attached to the wire.
3. He notes the maker's number of each thermometer before it is clamped to the temperature wire, in order to identify it beyond question when making the final corrections.
4. If water specimens are taken for specific gravities, he notes the fact, also the depths at which they were obtained.
5. He reports the expiration of the interval allowed by the officer in charge for the last thermometer of the series to take the temperature.
6. When the engineer starts to reel in he informs him where each instrument is attached.
7. He enters the officer's reading of each thermometer, calling back the figures distinctly, and verifies it by personal inspection, giving special regard to the degrees. If the readings disagree he calls the attention of the officer before he allows the thermometer to pass him.
8. He notes any apparent discrepancies in the temperatures and the failure of thermometers to act.
9. He enters the corrections in the appropriate column and notes the corrected temperatures.
10. He fills the blanks in the record book and makes such further entries as the occasion requires.

The following table, taken from the original record, illustrates the method of recording serial temperatures on board the *Albatross*. The observations followed a deep-sea sounding in which a depth of 2,022 fathoms was found, 42 minutes being required to complete it; 6 minutes were consumed in shifting the reels; 22 minutes in clamping the instruments to the temperature wire and veering 1,000 fathoms; 4 minutes were allowed for the last of the series to take the temperature, and 16 minutes were required to reel in and detach the thermometers.

Serial temperatures.

Turns.	Fathoms.	Maker's number.	Temperature.	Correction.	Corrected temperature.	Remarks.
			°	°	°	
946	Surface	....	74	0	74	Apr. 18, 1891.
921	25	69473	65.4	0	65.4	Latitude 20° 47′ 15″ N.
896	50	54815	59.3	—0.3	59	Longitude 106° 15′ 30″ W.
848	100	61755	54.6	0	54.6	Sounding.
754	200	69485	50.2	—0.4	49.8	A. m. 5 h. 5 m.; up 5 h. 47 m.
659	300	66665	45	—0.2	44.8	Serial temperatures.
565	400	63919	42.2	0	42.2	5 h. 53 m.; down 6 h. 15 m.
470	500	66724	41	+0.1	41.1	6 h. 19 m.; up 6 h. 35 m.
377	600	63903	40	—0.2	39.8	Time sounding, 42 m.
281	700	69477	38.8	—0.1	38.7	Serial temperatures, 48 m.
188	800	69480	38	+0.1	38.1	Total, 1 h. 30 m.
94	900	51451	37.9	—0.3	37.6	D. S. ther. Negretti & Zambra.
Surface	1,000	66735	37.2	—0.2	37	Fahr. scale.
Bottom	2,022	66735	36	0	36	H. C. F., recorder.

The numbers in column of turns indicate where thermometers are to be attached to correspond to depths in column of fathoms. The serial temperature observations completed, the reels are changed again and the machine prepared for sounding.

A HAUL OF THE TRAWL.

The trawl follows sounding and serial temperatures in natural order, and while they were being taken the dredging boom would be rigged and topped up, the dredge rope shackled to trawl, and the latter hoisted to boom end in readiness to be swung out.

Trawling and dredging are conducted by the commanding officer in person. He determines the direction in which the trawl will be laid out and dragged, and has the dredging boom rigged on what will be the weather or working side. In preparing to cast the trawl he is influenced in his choice of the working side by attendant conditions:

1. It is necessary that the dredge rope shall trend clear of the ship's side while towing; hence the direction of the haul with reference to wind and current must be such that the vessel will either make a true course or drift to leeward away from the rope.

2. He will follow the predetermined line of investigation as closely as practicable, and whenever obliged to deviate from it will adopt a course that most nearly approximates to it.

3. The most perplexing obstacle in the way of following a fixed line is often due to the contour of the sea bottom. It is difficult to trawl successfully down a steep slope; hence it becomes necessary to take the line of equal depths or to turn about and drag the trawl directly up the incline.

4. The direction and force of wind and current with reference to the line of investigation and contour of the sea bottom bear directly upon the plan of operations and determine the working side upon which the dredging boom is to be rigged.

The former practice of backing while casting the trawl and dragging it has been abandoned on account of the limited control the commander had over the course, which was always against the wind; for the natural tendency of a screw steamer is to bring

her stern to the wind when backing, and this tendency becomes a fixed habit whenever a trawl is dragging. On the other hand, the vessel is always under control when steaming ahead, and may work with the wind from a point on the bow to right astern, providing wind and current are in the same direction.

Starting ahead slowly, the trawl is swung out, lowered to the surface of the water, and towed until the frame assumes a horizontal position, and the trawl net, the pocket, the mud bag, and wing nets all trend aft and are seen to be clear.

When the vessel reaches her course under a speed of 2 to 3 knots, with the lee engine only working, the order is given to lower away. The first few fathoms should be veered with promptness and sufficient rapidity to insure sinking the trawl well below the propeller, after which the commanding officer will prescribe the rate at which it shall be veered and regulate the speed of the vessel. Under ordinary conditions it would be about 3 knots per hour, and the first 200 fathoms of dredge rope would be veered at the rate of about 30 fathoms per minute.

The engineer at the dredging engine calls out each 100 fathoms, the recorder notes the time and stands, watch in hand, ready to increase or check the rate of veering, which is never allowed to exceed the prescribed limit.

By the constant use of the dredging quadrant the commander knows the angle of the rope at all times during its descent and so regulates the speed of the vessel and rate of paying out that the sinking of the trawl is facilitated, at the same time guarding against its capsizing or the rope kinking, contingencies that inevitably follow too rapid veering of the latter or too low speed of vessel.

DREDGING TABLE No. 1.

Depth of water.	Speed of ship while lowering trawl.	Length of dredge rope required for a given depth of water.	Time required to veer each 100 fathoms of dredge rope.	Angle of dredge rope while lowering trawl.	Angle of dredge rope while dragging trawl.	Allowance of dredge rope for catenary curve.
Fathoms.	*Knots.*	*Fathoms.*	*Minutes.*	*Degrees.*	*Degrees.*	*Fathoms.*
100	3	200	3½	60	55	25
200	3	400	3½	60	55	44
400	3	700	3½	60	52	50
600	2¾	1,000	4	55	50	60
800	2½	1,200	4	50	44	90
1,000	2½	1,500	4	50	40	110
1,500	2¼	2,166	4	50	40	206
2,000	2	2,670	4	45	35	250
3,000	2	4,000	4	40	35	350

Absolute rules can not be laid down for lowering the beam trawl, as its rate of descent varies with the conditions, which are rarely the same during two successive casts and frequently change more than once in the same haul. Yet dredging table No. 1 shows approximately the method followed on board the *Albatross*, which, in the light of experience, is considered safe practice under normal conditions.

The angles in this table are from the vertical. The speed at which the trawl is dragged along the bottom is not given in the table. It is usually less than that in the column for lowering, but is so variable that the safest plan is to maintain the angle as nearly as possible by the use of the dredging quadrant, regulating the speed as required, regardless of the actual progress of the vessel through the water.

The scope of dredge rope is given for ordinary practice, yet for rapid dragging in comparatively shoal water three and even four times the depth is allowed.

The rate of 3½ minutes per 100 fathoms for veering the dredge rope has been maintained up to 2,000 fathoms or more, sometimes successfully, but it is running on

the verge of the danger line where the slackening of the vessel's speed or other unexpected occurrence might result in kinking it, capsizing the trawl, or fouling the net. The dredge rope is to the beam trawl what the string is to the kite. Hence the necessity for keeping a continuous strain on it while it is going down; otherwise it will lose its balance and finally capsize, as would the kite with a slackened string.

The horizontal drag resulting from tension on the dredge rope and the mean track of the trawl from surface to bottom is shown by the following data from Table 1 (p. 391), where the depth is 3,000 fathoms and length of rope 4,000 fathoms. The time occupied in paying it out is 2 hours and 32 minutes, or 152 minutes, during which the ship moved through the water 6,375 fathoms, at a mean speed of 2.55 knots per hour, or 42 fathoms per minute. The rope was paid out at the mean rate of 26.3 fathoms per minute, with a resultant drag of 2,386 fathoms, a mean of 15.7 fathoms per minute had the trawl remained on the surface, but it sank at the mean rate of 19.7 fathoms per minute, increasing the drag 1,414 fathoms, or 9.3 fathoms per minute. Thus the total horizontal drag was 3,800 fathoms, or a mean of 25 fathoms per minute.

The margin between the speed of ship and rate of veering rope grows broader as greater depths are reached and the length of rope increases, for the weight of the latter accelerates the forward movement of the trawl and assists in steadying it.

A beam wind is most favorable for lowering and dragging it, as the vessel will then drift well clear of the dredge rope and the speed is easily regulated, either with the engines or by the use of sail. Hauls have been made in deep water under sail alone when the conditions were favorable, thus economizing fuel and saving wear and tear of machinery.

If the vessel will not steer with the lee engine, as may happen under low speed, drag of trawl, and unused propeller, it should be stopped and the weather one used instead, as the drag will in a measure counteract the inclination of the vessel to fall off. The weather engine would be used habitually only for the possibility of the rope being caught in the propeller.

The requisite speed for lowering the trawl will be readily attained with the engines, but with fair wind and current the lowest speed might be too great for dragging after the trawl is landed on the bottom. In this case the engine may be stopped and the vessel allowed to drift, the rate being increased, if desirable, by the use of sail.

It has been found necessary in exceptional cases to slowly back an engine to retard the drift, and with an adverse wind and current it may be advisable to use both engines turning slowly rather than drive one at high speed.

The angle of dredge rope and the strain on it, shown by the accumulator scale, are watched very carefully after the trawl is landed, and increasing strain is noted. Should the increase be gradual and not excessive, it is an indication that the trawl is performing its function normally; but a sudden accession of 2,000 or 3,000 pounds signifies that the trawl has either encountered some obstruction, or buried itself in the soft ooze of the ocean bed.

Instant relief is afforded in either case, first from the dredging engine, which, having its friction clutch properly adjusted, allows the drum to reverse and the rope to run out until the strain is brought within the limit of safety, the vessel's headway being stopped in the meantime.

The rope is then hove short, the ship backing or steaming ahead slowly to relieve the strain, and in this manner she is placed directly over the trawl. If the trouble is due to its having caught on a ledge of rocks, or other ordinary obstruction, it can

usually be cleared by steaming slowly in the opposite direction from which it was laid out. Should this maneuver fail after repeated trials, it is safe to conclude that the trawl has buried. In this case the rope is hove in to the limit of safety, and the vessel allowed to ride to it until the strain is partially relieved, then hove in again, the operation being repeated until it is worked out of its bed. Then steaming slowly ahead, a portion of the load is washed out through the meshes of the net, which is finally hove up.

If all efforts fail, as sometimes happens, a steadily increasing strain is put upon the rope by going ahead, or backing, until the bridle stops part and the trawl comes up tail first, or the rope is broken and the trawl and its attachments lost.

An overload of stones, clay, or tenacious mud is perhaps the most trying, for the net can not be relieved from its weight and must be hove up with the greatest care, consuming much valuable time and, not infrequently, parting stops or rope just as it reaches the surface.

The trawl is dragged from half an hour to an hour and a half in deep water and becomes more or less filled with ooze, making it very heavy, hence it should be hove up slowly at the start, and until a portion of it has strained out through the meshes of the net, the vessel retaining a little headway until the depth of water exceeds the length of submerged rope; otherwise the steady pull on it will soon tow the vessel, and as she begins to move through the water the trawl will remain stationary, possibly sinking more deeply into the soft bottom, and become overloaded, while fish and other free-swimming forms that have not yet found their way beyond the pocket may swim out of the mouth of the net.

The vessel should, under no circumstances, be allowed to shoot ahead and override the rope, or slacken it sufficiently to allow it to kink, as it is prone to do, or to leave a bight lying on the bottom, for it will have to be dragged transversely through the ooze, which is sometimes a serious matter. Should the engine be stopped after trawling to windward, and the vessel be allowed to fall off with the rope trending out from the weather side, as would seem, at first thought, the proper thing to do, she will soon have the wind abaft the beam, lying at right angles to her former course and directly athwart the rope. In this position the helm is ineffective, and the rope can be hove in only as fast as the vessel drifts, for as often as it is exceeded the rope will draw tightly under her bottom, whereas had she rounded to and stopped with the rope to leeward she would have gathered steerage way and held a course sufficiently high to clear it until she had nearly reached the trawl, when she could have steamed around it until the boom was again to windward. During boisterous weather it is advisable to keep a little headway until the trawl is up. In the event of the sea being too heavy to land it safely, the vessel may be brought stern to, as in sounding, while the last 100 fathoms are coming in. She will then be in the best possible position for handling it.

The speed at which a trawl should be hoisted varies with the character of service, the depth of water, and state of the sea, the first consideration being to secure the specimens in the best possible condition. A speed that is admissible in 100 or 200 fathoms would destroy a large portion of the haul if maintained from a depth of 2,000 fathoms, and a rate that would be practicable in smooth water would be destructive in a heavy sea. It has been customary on board the *Albatross* to start very slowly until the maximum strain is reached, then to run in about 25 fathoms per minute under ordinary conditions, increasing the speed according to circumstances, following in a general way the rule given in dredging Table No. 1, for lowering the trawl.

Dredging Table No. 2 is taken from the original records of six hauls of the beam trawl, and shows a fair average of the *Albatross's* work under ordinary conditions:

DREDGING TABLE NO. 2.

Serial Nos.	Depth of water.	Scope of dredge rope.	Time per 100 fathoms going down.	Time trawl was dragged on bottom.	Approximate distance trawl was dragged on bottom.	Time per 100 fathoms coming up.	L. B. T.=Large beam trawl. S. B. T.=Small beam trawl.	Load in trawl net.
Station.	*Fathoms.*	*Fathoms.*	*M. S.*	*H. M. S.*	*Knots.*	*M. S.*	*Beam trawl.*	
2565	2,069	3,000	3 42	1 18 30	3.0	3 06	L. B. T.	Light.
2566	2,620	4,000	3 54	2 12 00	2.0	3 59	L. B. T.	Ordinary.
2570	1,813	2,700	3 36	1 13 30	1.0	3 45	L. B. T.	Do.
2571	1,356	2,200	3 50	1 23 30	1.0	3 55	L. B. T.	Do.
2572	1,769	2,800	4 00	0 55 40	0.5	4 54	L. B. T.	Heavy.
2575	1,710	2,600	4 12	1 31 00	1.0	4 24	S. B. T.	Ordinary.

The scope of dredge rope is greater than is given in Table 1, and serves to illustrate some of the exceptions to the rule there given.

In No. 2565 the excess was allowed for the purpose of rapid towing, as will be seen by the distance it was dragged. It was the first station occupied in the immediate neighborhood and it was assumed that the depth was practically uniform, but the succeeding sounding showed that it had increased 551 fathoms and that the trawl had kept the bottom but a short time. The rapid rate at which it was hove up resulted from the light weight in the net at the start, which gave the impression that it was a waterhaul and no harm could come from recovering it rapidly. A variety of bottom forms found in the net was, however, sufficient evidence of its having been on the botton.

In the next haul, No. 2566, allowance was made for increasing depth, and the speed was reduced, the results showing that the calculations were sufficiently accurate to secure an excellent haul.

In the two following hauls a liberal allowance of rope was given on account of the uneven bottom and the results were normal, but in No. 2572 the trawl encountered an elevation into which it cut, penetrating the covering of ooze and bringing up an overload of gravel.

During the haul No. 2574 the trawl encountered an obstruction from which it could not be cleared and it was lost, hence the use of a small trawl at No. 2575. It was handled with care, and hove up slowly to avoid injury to delicate specimens, as the net was intended for shoal water and did not afford as much protection as those designed for deep-sea work.

To land the trawl on deck, hoist it to the boom end, when the bag will hang a little above water, put a strap around it and hoist it inboard with the boom tackle, either by hand or steam. If it is found to have a heavy load when it reaches the surface, suspend it for a moment, with the lead rope just out of water, ascertain its weight, then run it up to the boom end, or put a running bowline around it and take part of the weight with a tackle, and when it is up put a strap around it below the bowline and hoist it on board with the tackle, assisted by the after boom guy if necessary.

The critical moment in landing a heavily laden trawl is when the bag leaves the water, for if it was near the limit of safety when submerged its increased weight in air might greatly exceed it. In the event of the load being too great to warrant

an attempt to land it, cut a slit in the net and allow a portion of its contents to escape. The small trawl net swings over the rail without the aid of strap and tackle.

To empty the trawl net, suspend it by the boom tackle, remove the mud bag, cast off the tail lashing, and allow the contents to run easily into the table sieve; wash the mud from the net with a hose, still holding it over the sieve that the specimens may fall into it, then lower it on deck; secure the contents of the wing nets by turning them inside out and rinsing them in a bucket of water; examine the trawl net, remove specimens that may adhere to it, repair rents, and prepare it for the next cast.

The mud in which the specimens are imbedded is washed from the table sieve with a steam hose, without nozzle, which affords an ample flow of water without force enough to injure the specimens. After they have been secured, the sieve should be thoroughly cleaned and the mud and water rinsed from the deck, in order to avoid the possibilty of mixing the hauls. A single specimen, even, out of place may throw discredit on the operations of a day.

The Blake deep-sea trawl is designed for use in great depths. It is operated practically the same as a beam trawl, over which it has the following advantages:

1. It has a lead rope on each side, and is right side up whichever way it lands. It may turn on its way down or while it is dragging without affecting the haul.

2. It may be lowered vertically until near the bottom, providing the pocket is properly lashed down and sufficient weight attached to tail of net to carry it down as rapidly as the frame will sink.

3. The course may be changed to any extent while lowering or dragging, providing the rope is not slackened.

The disadvantages compared with the beam trawl are:

1. The small sweep of lead rope.

2. A large volume of water rushes into the widely distended mouth during its ascent and injures the delicate specimens whenever they are unprotected by a covering of bottom soil in the bag. The facility with which it is operated and its certainty of action commend it for deep-water work, however, in spite of its faults.

The recorder keeps a full record of the haul, making the following entries:

1. The kind of trawl used.
2. Time of paying out each 100 fathoms of dredge rope.
3. Total length of dredge rope paid out.
4. Course and distance trawl is dragged on bottom.
5. Time the trawl is dragged.
6. Time required to heave up each 100 fathoms of dredge rope.
7. Load in trawl net—heavy, ordinary, or light.
8. General contents of the trawl net from his own observation, and such information as he can obtain from the naturalists.
9. Any matter of interest connected with the haul, as striking an obstruction, trawl burying in the bottom; loss or injury to rope, trawl, or other apparatus.

A haul of the dredge follows in case the trawl encounters foul ground or it is desired to collect mollusca or annelids that burrow in the bottom soil. It is operated in the same general manner as the Blake deep-sea trawl, and was formerly used instead of trawls for deep-sea work, but its scope is now confined to shoal water or moderate depths. The recorder keeps the same record as for a haul of the trawl.

A haul of the tangles follows if the bottom is too foul for the successful operation of trawl or dredge. The tangles are the simplest and most easily manipulated of all the various forms of apparatus for submarine collecting; they can be lowered vertically, if desired, more rapidly even than the dredge, and are expected to take their chances on the roughest bottom except they become locked under projecting rocks in such a manner that a reversal of direction is required to release them. A variety of forms are taken with the tangles, including starfish, sea-urchins, crinoids, corals, and even fishes of considerable size. The same record is kept as in trawling and dredging.

COLLECTING FROM INTERMEDIATE DEPTHS.

A haul of the Tanner intermediate tow net usually follows the trawl or dredge, as the possible change of depth would not affect its use unless observations are required near the bottom; then it follows the sounding. A dèscription of the apparatus and its use will be found under the title of "Surface and intermediate collecting."

The recorder notes:

1. Time required to veer each 100 fathoms of rope.
2. The depth at which the net is towed.
3. The length of rope out and angle at which it is towed.
4. Time and distance the net is towed.
5. Time of descent of messenger.
6. Time each 100 fathoms of rope was hove up.
7. General account of the contents of lower and upper nets.
8. Anything of interest in connection with haul.

TRIAL LINES.

Cod and halibut trial lines are extensively used in the exploration of fishing banks. They are operated by the crew from the ship's rail as she drifts slowly over the ground; if she drifts too rapidly, as she is liable to do in boisterous weather, her stern is turned to the wind and the vessel is held in position with the propellers, as in sounding. The use of trial lines from the rail is practically limited to depths within 70 fathoms. The fishery expert takes charge of the catch, examines every specimen, and keeps a record of—

1. The numbers and species of fish taken.
2. Weight of each fish.
3. Their length and general dimensions.
4. Parasites found on them, external and internal.
5. Food-contents of stomach.
6. General physical condition of catch.
7. Relative abundance.
8. Bait and apparatus used.

He preserves a sufficient number of specimens from each station to show the general condition of the various species of fish, their food (as shown by contents of stomach), and examples of parasites which are found upon them.

The recorder notes the number of lines used in the trial, the numbers and species of fish taken, the duration of the trial, and any further information obtainable.

Fishing trials from the rail with the vessel underway are limited to fifteen minutes or half an hour, and if further examination is required it is customary to anchor and send the boats out, or leave them to continue the trial while the ship engages in other work in the vicinity.

THE USE OF TRAWL LINES.

Whenever an examination is extended beyond ordinary limits trawl lines containing from 300 to several thousand hooks are employed. They remain on the bottom from an hour to half a day, the shorter interval being sufficient for codfish and some other species, but not for halibut, which are slow at taking the hook. The set is repeated as often as occasion requires.

The vessel remains by the trawl line, or works in the vicinity, according to circumstances.

GILL NETS.

These nets are occasionally used at sea, and may properly be included in the occupation of a station, though usually employed near land. They may be allowed to drift with the current, or anchored at surface, bottom, or at intermediate depths.

THE RECOGNITION OF MARINE DEPOSITS.

Having long felt the need of some simple and practical suggestions for the recognition of the various kinds of sea bottom, I appealed, through the good offices of the United States Fish Commission, to Dr. John Murray, of Edinburgh, Scotland, requesting him to formulate such brief and practical rules as would enable the marine surveyor to recognize the general character of deposits encountered in deep-sea exploration. In response, he kindly contributed the following comprehensive description of the various marine deposits, and methods of distinguishing them:

The marine surveyor will render excellent service to science by carefully examining and preserving for future study the samples of marine deposits brought up from various depths and positions on the ocean's floor during sounding and dredging operations. Recent investigations with reference to the composition and distribution of deep-sea deposits have led to important generalizations in geology and physical geography. It may be stated generally that the marine deposits found in shallow and deep water near shore are for the most part made up of mineral particles and detrital matters washed down from the dry land or torn away from coasts by the action of waves and currents, and hence called *terrigenous deposits.*

On the other hand, marine deposits on the floor of the ocean at distances beyond 100 or 200 miles from land are for the most part made up of calcareous and siliceous shells, secreted by organisms in the surface waters, which have fallen to the bottom; the mineral particles and clayey matter associated with these shells appear likewise to have, for the most part, fallen from the surface and to have been derived from floating pumice and volcanic and other dust showers. These deposits are called *pelagic deposits.* There is a great variety in these two great classes of deposits, and in passing seaward there is a gradual transition from the one to the other class. In those regions of the ocean toward the Arctic and Antarctic which are affected by floating ice the line of demarkation is further complicated by continental rock fragments and minerals being carried far to sea and deposited on areas of the sea bed which would but for this circumstance be occupied by purely pelagic deposits. Phosphatic, glauconitic, and calcareous concretions are more or less characteristic of terrigenous deposits, while manganese nodules, sharks' teeth, earbones of cetaceans, cosmic dust (magnetic spherules containing nuclei of native iron and nickel), and zeolitic crystals are sometimes abundant in pelagic deposits.

In examining a sample of a marine deposit the surveyor should note its color and any evidence of stratification into different layers, as well as the size of any mineral or organic particles as observed by the naked eye. If a portion of a sample be shaken up in a bottle with abundance of water the larger organic and mineral particles can be separated from the amorphous clayey and calcareous matter by decantations. If, after the water is poured off the larger particles, they be treated with a little spirits of wine and then a match be applied, the spirits of wine will burn away and leave the particles dry, so that they may be easily examined with a loup or low power of the microscope. The calcareous particles are usually of a white color, and consist, for the most part, of Foraminifera (*Globigerina*) or Pteropod shells. The former are more or less roundish in form and the largest seldom over one-thirtieth of an inch in diameter. The Pteropod shells are larger but much thinner than the Foraminifera. In the very deepest deposits the Globigerinæ are all removed, apparently owing to the solvent power of the water through which they have fallen. At lesser depths the thinner Pteropods disappear from the deposits before the Globigerina; it is therefore important to note the presence or absence of these two classes of shells in deep-sea deposits. The siliceous organisms, such as Diatoms and Radiolarians, are recognized by their transparent appearance and sharp, clean-cut edges.

If a portion of a sample be treated with dilute hydrochloric acid (1 part acid to 10 parts water) all the calcareous particles may be removed, and the mineral particles can thus be more conveniently examined. By this process also a rough estimate may be formed of the quantity of carbonate of lime in the sample, and this is one of the most important points in classifying deposits. The particles of quartz and felspars making up the larger part of terrigenous deposits near land are usually rounded, or can be recognized by their fractures and transparent appearance. The volcanic particles in pelagic deposits are usually of a darker color, with the exception of the splintered fragments of pumice or volcanic glass. Particles of peroxide of manganese, so frequent in the red clays and other pelagic deposits, can at once be recognized by treating with a small quantity of pure hydrochloric acid in a

white porcelain basin; the acid in a few moments dissolves the particles and passes away in a dark-colored stream.

In preserving samples for examination in the laboratory at home, the best method is to place the sample as procured in a glass bottle and to add a small quantity of spirits of wine.

The various kinds of marine deposits belonging to the two great classes have been named from the relative abundance and character of the organic or inorganic materials of which they are composed. The following is the nomenclature adopted by Dr. John Murray after an examination of the samples procured in various regions of the ocean by the *Challenger*, the *Tuscarora*, the *Albatross*, and other deep-sea expeditions:

I. Deep-sea deposits, beyond 100 fathoms.	Red clay; Radiolarian ooze; Diatom ooze; Globigerina ooze; Pteropod ooze.	1. Pelagic deposits, formed in deep water far removed from land.
	Blue mud; red mud; green mud; volcanic mud; coral mud.	2. Terrigenous deposits, formed in deep and shallow water close to land masses.
II. Shallow-water deposits, between low-water mark and 100 fathoms.	Sands, gravels, muds, etc.	
III. Littoral deposits, between high and low-water marks.	Sands, gravels, muds, etc.	

The term "ooze" is applied only to pelagic deposits made up chiefly of the remains of organisms, the term "clay" only to the red clay found in the deepest regions of the ocean, and the terms "mud" and "sand" only to terrigenous deposits.

It is unnecessary to enter into details as regards the shallow-water deposits, but the following notes on the deep-sea deposits, which term is applied to those from depths greater than 100 fathoms, may be appended:

A. Pelagic Deposits.

1. *Red clay.*—This deposit is spread over the greater depths of the ocean remote from land, and is the most widely distributed and probably the most characteristic of all deep-sea deposits. The *Challenger* took 70 samples in depths ranging from 2,225 to 3,950 fathoms, the average depth being 2,730 fathoms. The *Albatross* investigations have shown that this deposit is spread over a wide area in the northeastern Pacific. The amount of clayey matter and the color vary greatly in different samples, but red is the prevailing color, sometimes brick red, sometimes dark chocolate, sometimes bluish or gray. The immediate upper layer is thin, watery, and often has a lighter color than the deeper layers, which are much more dense.

The red clay is soft, plastic, and greasy to the touch. When dried it cakes into a hard, compact mass that can only be broken with the blow of a hammer. The hardened fragments assume a glazed appearance and characteristic shining streak when rubbed briskly with the finger nail or any hard, smooth body. In the greater depths carbonate of lime may be almost, if not entirely, absent, while in lesser depths it may rise to over 20 per cent, and is due principally to the remains of pelagic foraminifera, with a few coccoliths or rhabdoliths and other minute calcareous fragments. The remains of pelagic siliceous organisms are usually present, principally radiolarians and diatoms, along with sponge spicules and arenaceous foraminifera.

The principal mineral particles in a red clay are fragments of pumice and the mineral species usually found in its different varieties. There may be also fragments of basaltic glass, basalt, augite, andesite, and palagonite arising from the decomposition of the basic volcanic glasses. The peroxides of iron and manganese are found throughout the red clays in the form of minute grains or coatings. When deposited as concretions around organic remains and other nuclei, they form manganese nodules. In some red-clay areas thousands of sharks' teeth and earbones of cetaceans, more or less impregnated or coated with manganese, have been dredged, and zeolitic crystals of secondary formation (phillipsite) and cosmic spherules are sometimes met with.

The origin of the red clay has been the subject of much discussion. It is evidently not a residue or ash derived from the solution of calcareous organisms, as supposed by Wyville Thomson, but is derived from the decomposition of aluminous silicates and rocks spread over the floor of the ocean.

Average composition of the Challenger samples of red clay.

Carbonate of lime:		
Pelagic foraminifera	4.77	
Bottom-living foraminifera	.59	
Other organisms	1.34	
		6.70
Residue:		
Siliceous organisms	2.39	
Minerals	5.56	
Fine washings	85.35	
		93.30
		100

The term "fine washings" is used to indicate the amorphous clayey matter in a deposit left after treatment with dilute hydrochloric acid.

2. *Radiolarian ooze.*—This deposit resembles the red clay in most respects, but contains a much larger number of radiolarian shells, skeletons, and spicules, together with sponge spicules and frustules of diatoms. The *Challenger* samples ranged in depth from 2,350 to 4,475 fathoms, the average being 2,894 fathoms. There is usually only a trace of carbonate of lime, though it may rise to nearly 20 per cent, principally due to the remains of pelagic foraminifera, along with a few other calcareous fragments. Manganese nodules, palagonitic fragments, sharks' teeth, earbones of cetaceans, zeolitic crystals, and cosmic spherules have been found in nearly all the samples of radiolarian ooze.

Average composition of the Challenger samples of radiolarian ooze.

Carbonate of lime:		
Pelagic foraminifera	3.11	
Bottom-living foraminifera	.11	
Other organisms	.79	
		4.01
Residue:		
Siliceous organisms	54.44	
Minerals	1.67	
Fine washings	39.88	
		95.99
		100

3. *Diatom ooze.*—This deposit when wet has a yellowish straw or cream color. When dried it is nearly pure white, resembling flour. Near land it may assume a bluish tinge. The surface layers are thin and watery, but the deeper ones are more dense and coherent, breaking up into laminated fragments. It is soft and light to the touch when dried, taking the impress of the fingers and sticking to them like fine flour. Small samples appear quite homogeneous and uniform, but in all the *Challenger* soundings there were fragments of minerals and rocks, and gritty particles can generally be felt when the substance is passed between the fingers. The *Challenger* samples varied in depth from 600 to 1,975 fathoms, the average depth being 1,477 fathoms. The principal part of the deposit is made up of the dead frustules of diatoms, together with radiolarian remains, sponge spicules, and their fragments. The carbonate of lime varies from 2 to over 30 per cent, due principally to the dead shells of pelagic foraminifera. The mineral particles vary greatly in nature, size, and abundance, sometimes volcanic rocks and minerals, sometimes those of ancient and sedimentary formations predominating. This was to be expected, for all the *Challenger* samples lie within the region of floating ice in the southern hemisphere.

Average composition of the Challenger samples of diatom ooze.

Carbonate of lime:		
Pelagic foraminifera	18.21	
Bottom-living foraminifera	1.60	
Other organisms	3.15	
		22.96
Residue:		
Siliceous organisms	41.00	
Minerals	15.60	
Fine washings	20.44	
		77.04
		100

4. *Globigerina ooze.*—This deposit is white, milky yellow, rose, brown, or grayish, depending on the nature of the inorganic substances mixed with the foraminifera shells. The prevailing color is milky white or rose-color far from land, and dirty white, blue, or gray near land, when there is a considerable quantity of detrital matter from rivers in the deposit. It is fine-grained and homogeneous. In tropical regions many of the foraminifera are visible to the naked eye, while in temperate regions the form of the organisms is, as a rule, indistinguishable without the aid of a lens. When dried a globigerina ooze is usually pulverulent, but some specimens with a low percentage of carbonate of lime cohere slightly. The *Challenger* samples ranged in depth from 400 to 2,925 fathoms, the average depth being 2,002 fathoms. In addition to the pelagic foraminifera many other organisms contribute to the carbonate of lime in a globigerina ooze, some living in the surface waters, others at the bottom of the sea. Among the former are pelagic mollusks (pteropods and heteropods) and pelagic calcareous algæ (coccospheres and rhabdospheres with their broken parts, coccoliths and rhabdoliths), and among the latter are remains of mollusca, echinoderms, annelids, corals, polyzoa, and bottom-living foraminifera. The percentage of carbonate of lime varies from 30 to nearly 100 per cent, the estimated percentage due to the presence of the dead shells of pelagic foraminifera alone being usually

about 50 per cent of the whole deposit. The siliceous remains of radiolarians, diatoms, and sponge spicules are nearly always present, but usually in small quantity. In the purest samples of globigerina ooze mineral particles are exceedingly rare, and consist for the most part of a few minute fragments of feldspar, augite or hornblende, magnetite, volcanic glass, sometimes more or less altered, with which are associated a small quantity of clayey matter and the oxides of iron and manganese. In the less pure samples the mineral particles become more numerous, feldspar, augite, olivine, hornblende, and more rarely mica, bronzite, actinolite, chromite, glauconite, quartz, and cosmic dust being met with. The terms pulvinulina ooze, orbulina ooze, and biloculina ooze have arisen through a misconception, the samples examined having been passed through sieves and only the larger particles preserved. They are all really globigerina oozes.

Average composition of the Challenger samples of globigerina ooze.

Carbonate of lime:		
Pelagic foraminifera	53.10	
Bottom-living foraminifera	2.13	
Other organisms	9.24	
		64.47
Residue:		
Siliceous organisms	1.64	
Minerals	3.33	
Fine washings	30.56	
		35.53
		100

5. *Pteropod ooze.*—This deposit resembles the globigerina ooze in nearly all particulars, differing mainly in the greater abundance of the shells of pelagic mollusks (pteropods and heteropods principally), which sometimes makes up over 30 per cent of the deposit. In oceanic regions the deposit approaches in constitution a globigerina ooze, being, however, more friable and granular and less homogeneous and uniform from the presence of these larger shells, but the mineral particles are the same as in a globigerina ooze from the same region. Near the coast line the pteropod deposits resemble the terrigenous deposits in the large number of shore materials and organisms which enter into their composition, or fragments from coral reefs and calcareous organisms from shallow water may make up a large part of the deposit. The *Challenger* samples range in depth from 390 to 1,525 fathoms, the average depth being 1,044 fathoms. The percentage of carbonate of lime varies from over 50 to nearly 100 per cent, principally due to shells of pelagic foraminifera and pelagic mollusks. The remains of siliceous organisms are usually present in small quantity. Sometimes, however, they may make up nearly 20 per cent of the whole deposit. They are principally sponge spicules, radiolarians, diatoms, along with a few casts of foraminifera and arenaceous foraminifera. Mineral particles, principally magnetite, augite, feldspar, hornblende, etc., make up from about 1 to 10 per cent.

Average composition of the Challenger samples of pteropod ooze.

Carbonate of lime:		
Pelagic foraminifera	47.15	
Bottom-living foraminifera	3.15	
Other organisms	28.95	
		79.25
Residue:		
Siliceous organisms	2.89	
Minerals	2.85	
Fine washings	15.01	
		20.75
		100

B. Terrigenous Deposits.

6. *Blue mud.*—This name has been adopted for the deposits most frequently met with in the deeper waters surrounding continental land, and in all inclosed or partially inclosed seas more or less cut off from free communication with the open ocean. The materials of which the blue muds are principally composed are derived from the disintegration of continental land, and are very complex in character. When collected this deposit is blue or slate-colored, with an upper red or brown layer which had been in immediate contact with the water. The blue color is due to organic matter and sulphide of iron in a fine state of division, and these muds have, as a rule, when taken from the sounding tube, a smell of sulphuretted hydrogen.

The red or brown color of the thin watery upper layer is evidently due to the presence of ferric oxide or ferric hydrate, but as the deposit accumulates this oxide is transformed into sulphide and ferrous oxide in the presence of organic matter in the underlying layers. When dried the deposit becomes gray or brown, owing to the oxidation of the sulphide of iron. Sometimes the samples are

homogeneous; at other times the aspect is heterogeneous, owing to the presence of large fragments of rocks and shells and small fragments of calcareous organisms. When wet the deposit may be plastic and behave like a true clay, but as a rule these muds may be described rather as earthy than as clayey. The *Challenger* samples ranged in depth from 125 to 2,800 fathoms, the average depth being 1,411 fathoms. The percentage of carbonate of lime varies from a mere trace to over 30 per cent, consisting mainly of pelagic and bottom-living foraminifera along with other calcareous fragments.

The shells of pelagic species of foraminifera, which make up so large a part of a globigerina ooze, are not abundant nor universally distributed in the blue muds, the remains of shallow-water or bottom-living organisms predominating in many cases. The remains of siliceous organisms are usually present in small quantity, sometimes making up 15 per cent of the whole deposit, and consist of diatoms, radiolarians, sponge spicules, arenaceous foraminifera, and casts of the calcareous organisms in glauconite or some allied silicate. The mineral particles are mostly derived from the adjacent lands, and consist largely of the fragments and minerals of the various rocks forming the continents. The size of the mineral and rock particles varies much with the position; they are as a rule larger near the shore and smaller as the deep sea is approached, except in those regions affected by floating ice. More than half of the deposit is in many cases made up of the mineral particles, consisting largely of rounded grains of quartz, along with particles of older crystalline or schisto-crystalline rocks, quartzite, sandstones, and limestones. Among minerals, besides quartz, are orthoclase and plagioclase, green hornblende, augite, mica, epidote, etc.; glauconite can not be considered characteristic of blue muds, but is to be found in nearly all of them, though in limited quantity compared with the green muds.

Average composition of the Challenger samples of blue mud.

Carbonate of lime:		
Pelagic foraminifera	7.52	
Bottom-living foraminifera	1.75	
Other organisms	3.21	
		12.48
Residue:		
Siliceous organisms	3.27	
Minerals	22.48	
Fine washings	61.77	
		87.52
		100

7. *Red mud.*—Along the Brazilian coast of South America the terrigenous deposits offshore are different from the deposits found in similar positions along other continents in that they are all of a red-brown or red-brick color, apparently due to the large quantity of ocherous matter carried into the ocean by the Amazon, Orinoco, and other South American rivers, and distributed by oceanic currents along these coasts. Similar red deposits are formed in the Yellow Sea off the Chinese coast near the mouth of the Yang tse Kiang. Although organic matters are probably as abundant as in the deposits along other coasts, still they do not seem to be sufficient to reduce the whole of the peroxide of iron to the state of protoxide, nor does sulphide of iron accumulate here as in the blue muds.

It is a remarkable fact that there is no trace of the green-colored glauconitic casts of foraminifera and other calcareous organisms, nor of any of the glauconite grains which usually accompany these casts in other terrigenous deposits. There are a few spicules of siliceous sponges, but frustules of diatoms and the remains of radiolarians are exceedingly rare or wholly absent. In other respects this deposit resembles a blue mud. The *Challenger* samples varied in depth from 120 to 1,200 fathoms, the average depth being 623 fathoms. The percentage of carbonate of lime varies from 5 to 60 per cent, apparently depending more on proximity to the mouths of rivers than on depths. The shells of pelagic and bottom-living foraminifera are the most abundant of the calcareous organisms. The mineral particles range from 10 to 25 per cent, quartz being the most abundant.

Average composition of the Challenger samples of red mud.

Carbonate of lime:		
Pelagic foraminifera	13.44	
Bottom-living foraminifera	3.33	
Other organisms	15.51	
		32.28
Residue:		
Siliceous organisms	1	
Minerals	21.11	
Fine washings	45.61	
		67.72
		100

8. *Green mud and sand.*—In their composition, origin, and distribution these deposits resemble in many respects the blue and red muds. Their chief characteristic is the presence of a greater or less abundance of glauconitic grains and glauconitic casts of the calcareous organisms. These muds and sands are almost always developed along bold and exposed coasts, where no very large rivers pour their detrital matters into the sea. They contain, as a rule, many remains of calcareous organisms, mineral particles from the continental rocks, and a considerable quantity of clayey matter, although fine clayey or detrital matter appears always to be less abundant than in a characteristic blue mud. Along coasts where these deposits are laid down pelagic conditions appear to approach much nearer to the shores than where blue muds prevail, as, for instance, on the Agulhas Bank and off the Atlantic coast of the southern United States; to such an extent is this the case that, were it not for the presence of glauconite and the nature of the mineral particles, many of the green muds might equally well be called globigerina oozes.

The green sands differ from the green muds chiefly in being more granular in appearance, owing to the relatively small quantity of amorphous matter present, and are usually found in shallower water. The average depth of the *Challenger* samples of green mud is 513 fathoms, and of green sand 449 fathoms, the range of both classes being usually from 100 to 900 fathoms. The percentage of carbonate of lime varies to a great extent, the average being 25 in the muds and 50 in the sands, pelagic and bottom-living foraminifera being the principal constituents. The percentage of siliceous organisms may be as high as 50, usually higher in the muds than in the sands, and they are principally glauconitic casts of calcareous organisms along with diatoms, radiolarians, sponge spicules, and arenaceous foraminifera. The mineral particles usually make up a large part of the deposit, sometimes nearly 80 per cent, the grains of glauconite being the most characteristic, along with quartz, felspar, magnetite, hornblende, augite, etc., and fragments of continental rocks. In the green sands there are frequently nodules and small concretions of phosphate of lime.

Average composition of the Challenger samples of green mud and green sand.

	Green mud.		Green sand.	
Carbonate of lime:				
Pelagic foraminifera	14.59		21	
Bottom-living foraminifera	2.94		15	
Other organisms	7.99		13.78	
		25.52		49.78
Residue:				
Siliceous organisms	13.67		8	
Minerals	27.11		30	
Fine washings	33.70		12.22	
		74.48		50.22
		100		100

9. *Volcanic mud and sand.*—Around oceanic islands of volcanic origin the deposits consist in a large measure of the rocks and minerals arising from the disintegration of the volcanic rocks of the islands. Near shore, within the region of wave action, these are largely sands composed of volcanic material and the fragments of calcareous organisms which vary much in size. In deeper water, further from the islands, the mineral particles become less abundant and smaller, while pelagic organisms, such as foraminifera, and pteropod shells, coccoliths, and rhabdoliths, increase in number so that the deposit assumes the character of a mud in which there is a considerable quantity of clayey and calcareous matter, light gray, brown, or black in color, and of an earthy rather than a clayey character. These deposits may be found along any coast where volcanic rocks prevail, but they are characteristically developed around the volcanic islands of the great ocean basins. In general appearance and composition they present great variety, depending on position, depth, and the organic remains that take part in their formation, their chief characteristic being the relative abundance of volcanic materials.

The *Challenger* samples of volcanic mud range in depth from 260 to 2,800 fathoms, the average depth being 1,033 fathoms; the samples of volcanic sand range from 100 to 420 fathoms, the average depth being 243 fathoms. The amount of carbonate of lime varies greatly, sometimes rising to 70 per cent, principally due to the remains of pelagic and bottom-living foraminifera. Siliceous organisms are rare, always under 5 per cent, consisting of radiolaria, sponge spicules, diatoms, and arenaceous foraminifera; true glauconitic casts and grains are absent. The mineral particles make up a considerable portion of the deposit, sometimes rising to 80 per cent; the most characteristic are sanidine, plagioclases, augite, hornblende, rhombic pyroxenes, olivine, and magnetite. Among the lapilli the most frequent are those belonging to the basaltic and andesitic series of rocks, especially those belonging to the vitreous varieties, and they are often decomposed into palagonitic matter.

Average composition of the Challenger samples of volcanic mud and volcanic sand.

	Volcanic mud.		Volcanic sand.	
Carbonate of lime:				
Pelagic foraminifera	10.50		13	
Bottom-living foraminifera	2.82		3.80	
Other organisms	7.17		11.99	
		20.49		28.79
Residue:				
Siliceous organisms	1.82		1.40	
Minerals	40.82		60	
Fine washings	36.87		9.81	
		79.51		71.21
		100		100

10. *Coral mud and sand.*—Just as around volcanic islands the deposits are principally made up of the débris from volcanic rocks, so off coral islands and coral reefs the deposits are chiefly made up of the fragments of organisms living in the shallow waters and on the reefs, such as calcareous algæ, corals, mollusks, polyzoa, annelids, echinoderms, and foraminifera. These fragments form a coarse sand or gravel in the shallower waters, but beyond the limits of wave action there is a fine mud, consisting principally of triturated particles of calcareous matter. With greater depth and increasing distance from the land, pteropod and heteropod shells, as well as pelagic foraminifera, make up more and more of the deposit, till the coral muds and sands pass finally into a pteropod or globigerina ooze, in which reef fragments can with difficulty be recognized.

The *Challenger* samples of coral mud ranged in depth from 140 to 1,820 fathoms, the average being 740 fathoms. The samples of coral sand were all in depths less than 300 fathoms, the average being 176 fathoms. The percentage of carbonate of lime is very high, in some cases over 90 per cent, principally due to the remains of pelagic and bottom-living foraminifera, though the remains of other calcareous organisms derived from the reefs are much more abundant than in any of the other types of deep-sea deposits. Siliceous organisms are more abundant in the sands than in the muds, owing to the smaller quantity of minute clayey and calcareous amorphous matter, consisting of sponge spicules, diatoms, and radiolaria. Mineral particles are rare in both varieties, consisting of feldspar, augite, etc.

Average composition of the Challenger samples of coral mud and coral sand.

	Coral mud.		Coral sand.	
Carbonate of lime:				
Pelagic foraminifera	31.27		36.25	
Bottom-living foraminifera	14.64		20	
Other organisms	39.62		30.59	
		85.53		86.84
Residue:				
Siliceous organisms	1.36		5	
Minerals	1		3.75	
Fine washings	12.11		4.41	
		14.47		13.16
		100		100

LIBRARY.

The ship's library contains over 400 volumes, under the headings of natural history, scientific, publications of the U. S. Fish Commission, National Museum, and Smithsonian Institution, navigation and nautical astronomy, steam, history, biography, etc. It is the intention to provide such works as will be useful in all branches of investigation carried on by the vessel, text-books and professional works required by the officers, besides a few standard volumes of history and biography.

PREPARATION AND PRESERVATION OF SPECIMENS.

The methods followed on board the *Albatross* will be briefly described; and the location and arrangement of the laboratories with the facilities they offer for the work of the naturalist will be referred to again, more in detail, in order to give a better understanding of the descriptions that follow.

They are located near the middle body of the vessel, at the point of least motion, forward of and free from the heat of the furnaces and vibration of the engines, where the naturalist may safely leave specimens and apparatus lying on tables and about the decks at times when in other parts of the vessel they would require to be carefully secured.

The upper laboratory, in the deck house, 14 feet in length, 12 feet 6 inches wide, and 7 feet 3 inches high, has a large skylight overhead, two windows, and one door on each side, and a door communicating with the stateroom of the resident naturalist. A small chemical laboratory occupies one corner of the forward end, nearly the whole after bulkhead being covered by a book case in which an extensive professional library is kept, while in the center of the room stands a table about 5 feet square, around which four persons may seat themselves, each having at his right hand a tier of drawers conveniently arranged within frames which form the legs of the table.

A false cover, surrounded with a 3-inch ledge, water-tight, is used at sea to prevent specimens, etc., from sliding off in heavy weather; also to prevent the dripping of muddy water on deck. Over a lead-lined sink are faucets for water and alcohol, both leading from tanks, and above them, attached to the bulkhead, are two small aquaria, with water connections, used for the study of marine life. An ample supply of natural light and ventilation by day and an abundance of electric light at night combine to make it an admirable operating room.

The lower laboratory is on the main deck directly beneath the upper one, its only means of access being by a stairway leading down from that apartment. It occupies a space of 20 feet fore and aft, and extends entirely across the vessel. It receives light and natural ventilation from three large air ports on each side and two movable deck lights 12 inches in diameter; it has also the means of artificial ventilation and electric lights. The forward bulkhead is covered with specimen cases of sufficient capacity to hold the glass jars and bottles filled during an ordinary trip, and there are appropriate lockers for copper tanks in which the larger forms are preserved. Work tables are ranged along the sides, a chemical table with appropriate lockers and drawers on the after bulkhead, a photographic dark room with a large lead-lined sink and running water on the port side, and on the starboard side a medical dispensary.

The arrangement of the specimen case is simple and convenient. Its face is composed of a row of wire paneled doors about 2 feet 6 inches wide and 4 feet high, each having independent fastenings. Opening a door, from three to six sliding drawers,

2 feet 6 inches square and 6 inches high, are seen, one above the other, resting upon cleats. The drawers are filled with empty glass jars and bottles preparatory to a cruise; when required for use a drawer is withdrawn and is carried to the operating room, where it remains until the bottles are filled, when it is returned to its appropriate place in the case. Following this system the losses by breakage, even in the worst weather, are reduced to the minimum.

Copper tanks for alcoholic specimens are of three standard sizes—4, 8, and 16 gallons; special tanks are of any size or shape desired. They are carefully made of heavy material, thoroughly tinned inside, and closed with circular covers as large as the dimensions of the tanks will allow; they are without hinges, being secured by four thumbscrews, working through small projections placed at equal distances around the circumference of the covers. The joints are made on rubber gaskets. The tanks are furnished to the ship in wooden transporting cases having strong iron handles and hinges, the covers being secured by padlocks. The cases contain four 4-gallon, two 8-gallon, or one 16-gallon tank each, and, the tanks fitting snugly, it is only necessary to lock the cases to prepare them for shipment.

The laboratory storeroom is under the lower laboratory and can be entered only from the latter. Specimen cases of the laboratory are duplicated in the storeroom, which has also conveniently arranged lockers and bins for the safe carriage of alcohol in barrels or tanks and the storage of specimens of all descriptions, including the supplies and varied apparatus belonging to the scientific department. It is lighted by electricity, ventilated artificially, and, in case of fire, can be instantly closed from above and filled with steam. The storeroom receives little or no heat from the fireroom, as large coal bunkers lie between.

LABORATORY OUTFIT.

A complete schedule is considered unnecessary, but the following partial list of articles included in the scientific outfit will enable the reader to form a general idea of the appliances used in the laboratories of the *Albatross:*

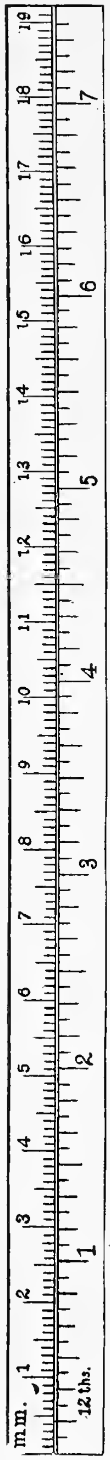
Partial list of laboratory outfit.

Acids, picric, chromic, etc.
Alcohol, barrels and tanks.
Alum.
Antimony.
Anvil.
Arsenic.
Axes.
Bags, rubber.
Blast, sand.
Boxes, nests, assorted.
Boxes, small, assorted paper.
Bottles, glass, assorted.
Buckets.
Camera lucida.
Camera, photographic, with accessories.
Chisels, cold.
Chisels, mortising.
Clay for making casts.
Cloth, bolting, silk.
Cloth, cotton, cheese.
Cutters, wire.
Dippers, galvanized iron.
Dippers, galvanized iron, fine wire-cloth bottom.
Dishes, assorted, glass and earthenware.
Drills, twist, assorted.
Envelopes, letter and note.
Filter.
Forceps.
Gun, whale.
Hammers, blacksmith.
Hammers, riveting.
Hatchets.
Harpoons.
Hydrometer, glass, for alcohol.
Jars, glass, with corks, eight sizes.
Jars, fruit, glass, pint, quart, 2-quart.
Jars, butter, glass, 2-pound, 4-pound.
Knives, cartilage.
Knives, dissecting.
Knives, oyster.
Lamps, electric, hand, and submarine.
Lance, bomb.
Microscope, with accessories.
Nets, surface, silk bolting-cloth.
Nets, tub strainer, linen scrim.
Paper, English white tissue.
Paper, manila.
Paper, letter and note.
Paper, straw.
Pails, wooden.
Pans, large, galvanized iron.
Pans, marbleized, assorted.
Pistols, collecting.
Plaster, for models and casts.
Potash.
Presser, cork.
Rings, brass, surface net.
Rings, galvanized iron, surface net.
Rule, common 2-foot.
Rule, millimeter.
Rifle, .32 caliber.
Shotguns, 12 bore.
Shotguns, 10 bore.
Scissors.
Sieves, assorted.
Shears.
Shovels, common.
Spades, common.
Spades, trenching.
Still, copper.
Syringes, hypodermic.
Tanks, copper, alcoholic specimen.
Tools, carpenter's chest.
Tubs, wash, large size.
Vials, homeopathic, assorted.
Vise, bench.
Vise, hand.

THE METRIC SYSTEM.

The metric system is in general use by naturalists for the measurement of fish and other forms. A meter is the standard of linear measure. It is the ten-millionth part of a quadrant of the meridian, or 39.370 inches. A meter equals 10 decimeters, 100 centimeters, and 1,000 millimeters.

The accompanying scale of English inches and millimeters furnishes a convenient method of comparison and conversion, one into the other.



Cut 76.—Comparative scale of linear measure, inches and millimeters.

GENERAL REMARKS ON PRESERVATION OF SPECIMENS.

The data from which the following description of the methods of preserving specimens obtained by the collecting apparatus is compiled were kindly furnished by Messrs. James E. Benedict, of the Smithsonian Institution, and C. H. Townsend, resident naturalist of the *Albatross.* I have also quoted freely from Bulletin No. 39 of the National Museum.

The chief object of the deep-sea investigator is to obtain accurate information regarding life in the waters of the ocean and the physical conditions under which it exists, rather than the discovery of new and wonderful forms, each successful haul of trawl or dredge being made to do its part.

In operating the collecting apparatus and before it reaches the surface, the officers of the ship have given the station a serial number, located it astronomically, and recorded its physical conditions, the depth of water, character of the bottom, temperature of the air, surface, and bottom, specific gravity, currents, etc., and when the specimens are identified and described their names will ever after be linked with that particular station. Hence one's best work, or that of other investigators, will be discredited or worse by carelessness on the part of those having charge of the handling and preservation of specimens. A label giving a wrong station number, a trawl net not well shaken out and picked over, specimens carelessly left in the corners of the table sieve or on deck, where they may become mixed with the contents of a subsequent haul at another station, will falsify the record, perchance beyond the possibility of correction. If there is a doubt as to the station to which a specimen belongs, give it the date and any other available information, but no attempt should be made to supply a station number by guesswork. No label at all is better than a false record.

The contents of the trawl having been landed in the table sieve (plate XXXIV), the net should be carefully examined for hydroids, corals, or other delicate forms that are often found entangled in the meshes, clinging to the web, or caught on the frame, and in this seemingly accidental way valuable specimens may be taken in good condition that would be liable to serious damage if imbedded in the mud and general contents of a haul.

The fish found in the table sieve are picked out and placed in buckets or tubs of clean water; the invertebrates are assorted in a general way into pans, dishes, or sieves; the deck hose, without nozzle, is used to wash the mud through the grated bottom of the table sieve, care being taken not to injure the specimens. It is

turned aside from time to time while the more delicate forms are picked from the surface of the mass or from the meshes of the sieve.

After the specimens resulting from the haul are gathered from net and sieve they are taken to the laboratory for assorting and preservation, a process usually quite simple, yet requiring experience and good judgment.

Alcohol is the preserving medium heretofore in general use. To insure its successful application, most specimens require to be first placed in a weak solution which, as it permeates the tissues, should be changed to stronger, thus completing the preserving process before they have time to soften and decay. An alcoholic mixture of 75 per cent is regarded as sufficient for the permanent preservation of well-cured specimens, although some require a stronger fluid, while others are equally well preserved in a weaker solution.

The necessity for a weak preliminary bath is illustrated in the case of a large fish of firm texture, which if thrown into strong, warm alcohol will quickly harden on the exterior, thus excluding the preserving fluid from the inner tissues and causing them to soften and decay. On the other hand, if it is subjected to a weak mixture of 35 to 50 per cent of cool alcohol, the fluid will penetrate the whole structure, after which the strength may be safely increased as desired.

The condition of alcoholic specimens collected in hot climates depends to a certain degree upon the temperature of the preservative when it is applied, a fact which has not always been given due consideration. The simple reduction of the alcoholic mixture by the addition of water raises its temperature from 10° to 20°, which, added to the constant heat of the surrounding atmosphere, greatly increases the difficulties attending the process of preservation.

Mr. James E. Benedict, when resident naturalist of the *Albatross*, adopted the plan of cooling alcoholic mixtures actually in use in the tropics by surrounding the tanks with ice, and as a further precaution he placed very delicate specimens in the cold room while they were absorbing the preservative, the cooling process being attended with excellent results.

TO PRESERVE FISH.

Wash them in clean water, and if more than half a pound in weight make an incision on the right side, just above the middle of the belly, to admit alcohol freely into the body cavity—the position of the cut leaves the left side intact in case a drawing or photograph should be required—then lay them out in dishes or pans of weak alcohol. After soaking a sufficient time, use the hypodermic syringe freely, if the body cavity has not been cut, injecting 95 per cent alcohol; then wipe carefully, wrap them in cheese-cloth, and pack them in jars or tanks containing alcohol of sufficient strength to maintain it permanently at 75 per cent. The soft and spongy tissues of deep-sea fish are rapidly permeated by the preserving fluid, and if full-strength alcohol is injected into the intestinal canal and body cavity it will rarely be necessary to make an incision.

Specimens designed for exhibition should be hardened slowly and retained in a natural position during the process, which may easily be done by securing them to a woven-wire screen of about half an inch mesh, seizing soft pine blocks under the expanded fins. In the preparation of specimens for this purpose it is well to remember that the nearer the temperature of the alcoholic solution approaches to 40° F. (the point at which decay of animal tissue is arrested) the weaker the first bath may be made, 25 per cent or even less being allowable, thus advantageously prolonging the hardening process, which in any event can not be delayed more than a few hours.

In placing specimens in jars or bottles while they are flexible, care should be taken that the receptacles are large enough to permit of their removal after the hardening process is complete, otherwise one or the other will be injured, and it is needless to say an experienced person will invariably sacrifice the jar.

It is common practice to use, for the first bath, old alcohol that has become too weak for other purposes.

THE PRESERVATION OF CRUSTACEA.

To preserve crabs, kill them in a dish of weak alcohol, placing a few in at a time lest they tear each others legs off in their struggles. When they become quiet, place them on separate pieces of cheese-cloth, backs down, fold the legs as naturally as possible, wrap them up, and tie the packages with soft twine. If any of the legs have become detached, as sometimes happens, place them in their natural position and wrap them up with the specimen. Inject large crabs with 95 per cent alcohol.

Wrappings may be dispensed with if desired in the case of small crabs, and it is always admissible when only a single specimen is placed in a bottle, yet it is good practice and but little trouble to wrap them in tissue paper, and if they are prepared in this manner the receptacle may be filled with specimens and 80 per cent alcohol turned upon them.

The various species of shrimp and all the coarser crustaceans may be treated practically the same as the crabs; only the larger forms require injecting.

THE PRESERVATION OF MOLLUSCA.

All mollusks may be preserved in alcohol, although it is unnecessary in the case of shells that are to be cleaned and dried. The animals may be killed with weak alcohol or hot water, and the soft parts removed with hooks or forceps.

Ascidians, octopods, and all of the naked soft-bodied mollusks are preserved in alcohol, first receiving a weak bath, the larger forms only requiring to be injected. Specimens of this class should be separately wrapped in cheese-cloth and protected from contact with the metal of the tank or each other by a liberal distribution of excelsior, tissue paper, or other suitable material. The tanks should not be more than half filled until the alcoholic solution permeating the mass has reached a strength of 75 per cent; they may then be filled, providing the specimens will not be injured by their own weight.

THE PRESERVATION OF ECHINODERMS.

Starfish and sea-urchins may be preserved in alcohol or dried; in either case a weak alcohol bath is desirable, as it expels a disproportionate amount of water, improves the condition of the specimens, and shortens the process of drying should they be preserved in that manner.

The tanks may be entirely filled with the ordinary hard-shelled sea-urchins, using 95 per cent alcohol, but the soft-shelled species require a cheese-cloth wrapping and excelsior protection in the tanks. Hard and firm starfish, like most of the deep-sea species, may be removed from the first bath, piled one upon the other to make convenient packages, wrapped in cheese-cloth, and placed in tanks with 75 per cent alcohol, where they will keep indefinitely.

The shoal-water species are usually soft, thickly covered with slime, and much distorted when they reach the laboratory. In this case place them in water while yet

alive, and as soon as they have filled out transfer them quickly to weak alcohol and adjust their arms during the process of hardening. If they are to be dried, place them in a solution of arsenate of soda for a few minutes after they are removed from the first bath to protect them from the attacks of insects. If they are to be preserved in alcohol, remove the slime with a brush, make them up in packages wrapped with cheese-cloth, and treat them as deep-sea starfish. They are sometimes dipped in hot water in preparation for drying, but the alcohol bath is to be preferred.

Holothurians should be kept in a weak bath three or four hours, then injected, wrapped in cheese cloth, placed in tanks containing 90 per cent alcohol, and protected from pressure by excelsior.

Crinoids, actinians, small corals, etc., may be treated in the manner above described for starfish and holothurians. Large corals, too bulky to be preserved in alcohol, are cured with great difficulty on board ship, yet they may be safely and conveniently transported by first hanging them up until the water is drained from them, the process being accelerated by spraying the specimen with old alcohol, then packed in common salt, using a barrel or box as most convenient, taking care to pack the salt snugly around the branches to give them proper support.

The coral should be surrounded with a sufficient quantity of the preservative to absorb all of its moisture without forming brine. If salt is not available, clean, dry sand may be substituted, providing it is excluded from the delicate septa by wrapping the specimen in cheese-cloth or other suitable material. Large sponges may be prepared and transported in the same manner.

Other invertebrates are usually preserved in alcoholic mixtures, although some may be dried. Jelly-fish should be hardened in a saturated solution of picric acid, subjected to a preliminary bath in weak alcohol, wrapped separately in cheese-cloth, placed in alcohol of 90 per cent, and surrounded with excelsior to protect them from pressure. Another simple and effective method of protecting delicate, soft-bodied forms from undue pressure in tanks is to place them in thin wooden packing-boxes, in which holes are cut to allow free circulation of alcohol.

THE COLLECTION AND PRESERVATION OF MINUTE FORMS.

Our remarks have thus far been confined to forms of sufficient size to be readily seen and picked out singly from the mass in the table sieve, yet there are in every successful haul of dredge or trawl a multitude of minute invertebrates demanding the careful attention of the collector.

The process of washing the mud from the specimens through the meshes of the table sieve into the tub strainer (plate XXXIV) has already been described. When it has been relieved of its contents the strainer bags will contain more or less mud, foraminifera, shells, and other light matter, while the heavier material has settled to the bottom of the tub, the final disposal of which depends upon the time the collector is able to devote to it.

A very satisfactory examination may be made by first turning the contents of the strainer bags, four or five quarts at a time, into a small tub partially filled with water, stirring the contents with a rapid, whirling motion until the soft, light forms float to the surface, when it is strained into another tub through a 20-mesh sieve, the contents of the latter being placed in a pan of water, repeating the operation until all the mud

in the tub strainer has been washed. The water and sediment thus collected in the small tubs and pans are then agitated and strained as before until the residue, composed of minute animal forms, free from mud, is placed on a 40-mesh sieve, and the latter set an inch or more above the mesh into a dish of weak alcohol, partially floating the specimens, where it is allowed to remain half an hour, then transferred to a stronger solution for an hour, when the mass may be placed in bottles or jars with 80 per cent alcohol. The receptacles should be kept at hand for a day or two and occasionally turned over to loosen the mass and insure its being properly cured, after which it may be packed away with safety.

Jars or bottles should not be more than one-third filled with material of this character, which may be said to include shrimp, all kinds of minute crustacea, worms, and, in fact, all forms, surface and deep-sea, that are liable to mat down in the jar. Striking objects or very delicate forms should be put separately into vials.

Foraminifera may be preserved by drying or in alcohol; in the latter case place it in jars with 95 per cent alcohol, turning it over occasionally for a day or two. The jar should not be more than half full of material. If to be dried, place in weak alcohol for a few hours, stirring the mass frequently, then spread it in pans or trays to dry.

Surface and intermediate collecting, including apparatus and methods, have been described on page 369 to the point where the specimens are removed from the nets to buckets or pans of water. The latter is then strained through a sieve of 40 mesh, which, with the specimens retained on it, is placed in a dish containing a saturated solution of picric acid for half an hour, when the larger and more striking specimens may be picked out and the remainder placed in bottles or jars containing 80 per cent alcohol.

FORMALIN.

This liquid has recently been introduced as a preservative, and although it has not been in use long enough to thoroughly establish its value and limitations, it has already proved itself a useful adjunct and bids fair to rival alcohol for many purposes. It is cheaper than alcohol, is not inflammable or explosive, and is put up in 1-pound (about 1 pint) bottles of convenient form for transportation, a couple of bottles capable of making from 2 to 10 gallons of preservative being easily carried in a hand bag. Its great value for fieldwork is already acknowledged, and it is generally conceded by collectors that it is unexcelled as a medium for preserving soft-bodied forms.

Mr. James E. Benedict, of the Smithsonian Institution, has specimens of fish in a good state of preservation, both in texture and color, that were cured more than a year ago in a solution of 1 part of formalin to 40 parts of water.

Prof. B. W. Evermann, of the United States Fish Commission, has fish and other forms that have been preserved a year and a half in 3 parts of formalin to 40 parts of water, all in excellent condition.

Should there be a doubt as to the continued safety of formalin specimens cured in the field, alcohol may be added to the solution after they reach the laboratory, or they may be transferred to alcohol, the two preservatives seemingly working together to their mutual advantage. Formalin does not freeze, although the solution used as a preservative will; freezing may, however, be avoided by adding a sufficient quantity of alcohol.

LABELS.

The importance of properly labeling specimens has already been referred to and must be apparent to all collectors. The ship's name, date, and serial number of the station is usually considered sufficient, further information being recorded under the corresponding number in the naturalist's journal.

If labels with properly printed headings are not at hand it is better to write them with a soft lead pencil on unglazed paper rather than use ordinary ink, which is liable to fade in alcohol. A small metal label, on which the serial number is stamped, is used on board the *Albatross* for labeling deep-sea fish and other forms. There is a hole in one end through which the seizing is passed with which to attach it to the specimen. The serial number is usually sufficient identification, yet the addition of an initial letter, or other arbitrary symbol for each vessel, would enable one to place the specimen on sight without the necessity of referring to the records.

BRIEF DIRECTIONS AS TO COLLECTING BIRDS.

Guns.—The best gun for general collecting is a 12-gauge double-barreled shotgun, with 28 inch barrels. Each gun should be furnished with an auxiliary barrel, .32 caliber, for collecting small specimens. A .22-caliber breech-loading pistol, with 18-inch barrel, is much used on board the *Albatross.* A .32-caliber rifle will be found useful in collecting the larger birds.

Ammunition.—Only the best powder should be used, black powder for the 12-gauge, American wood powder, D grade, for .32 caliber, and E for .22 caliber. Shot for the 12-gauge gun, Nos. 4 and 3; for the auxiliary barrel and pistol, Nos. 12 and 8.

For skinning birds a pocket knife, or scalpel, a pair of sharp-pointed scissors, a pair of bone-cutters, and spring forceps are all the tools necessary. A needle and thread will be required if the skins are to be stuffed. Raw cotton is best for filling the skin. Arsenic is the best preservative, and the skin should be covered with it before stuffing or packing.

A game bag or fishing creel will be found convenient for carrying birds while collecting. The specimen when shot should be picked up by the feet, to prevent the blood from soiling the plumage; remove blood clots from the bill and shot-holes, sprinkle moist feathers with corn-meal, sand, or other absorbent, push a plug of cotton well down its throat, and place it, head down, in a cornucopia of thick brown paper, which may then be placed in the creel. These precautions are taken for the purpose of securing the specimen with its plumage in the best possible condition, free from blood or other liquids. To kill a wounded bird squeeze it under the wings with thumb and finger until it dies from suffocation. If the bird is of large size, hold it firmly by the feet, or between the knees, and plunge a knife into its breast, reaching the heart if possible, then hold it by the feet until the blood has drained from its mouth, when it may be prepared for transportation practically as above described for small birds. Specimens should be skinned as soon as possible, though in cold weather or when ice is plentiful it may be delayed a reasonable time.

Birds were skinned on board the *Albatross* on the operating table in the upper laboratory; in the center of the table was placed a box of arsenic and a small brush, a box of corn-meal, or other absorbent, and a basin of water. At the side of each operator were skinning tools, a roll of cotton, a towel, sponge, needle and thread, labels, pencil, and a ball of twine.

Few measurements were taken as a rule, except in the case of a new species or some peculiarity in form. The coloring of bills, legs, feet, etc., was noted. The girth of the specimen was taken by wrapping a strip of paper around the body over the wings, and pinning it like a band, then slipping it off toward the tail and using it as a guide in stuffing the skin in order to retain the original size of the bird.

The process of skinning was much the same as that in general use among collectors, and may be briefly described as follows: Make an incision through the skin from the breast-bone to the anus, taking care not to soil the feathers or mutilate the sexual organs. Separate the skin on one side to the knee, expose the thigh, thrust the knee up on the abdomen, and loosen the skin around it until you can, with scissors or knife, separate the joint and muscles. Repeat the operation on the other side; loosen the skin about the base of the tail, and cut through the vertebræ at the last joint, taking care not to sever the bases of the quills; invert the skin and loosen it from the body. Loosen the skin from the first bone of the wings, and cut through the middle of it, or separate it from the body through the joint and draw the skin over the neck until the skull is exposed.

Detach the delicate membrane of the ear from its cavity in the skull without cutting or tearing it; then, by means of the thumbnails, loosen the skin from other parts of the head up to the eyes, taking care not to lacerate the balls. Scoop out the eyes, and, by making one cut on each side of the head, through the small bone connecting the base of the lower jaw with the skull, another across the roof of the mouth behind the base of the upper mandible and between the jaws of the lower, and a fourth through the skull behind the orbits and parallel to the roof of the mouth, you will have freed the skull from all accompanying brain and muscle. Should anything still remain remove it separately. In making the first two cuts do not sever the small bone extending from the base of the upper mandible to the base of the lower jawbone. Invert the skin of the head to the base of the bill, and clean off all the muscle and fat from the head and skin of the neck. Corn-meal should be used freely between the skin and carcass during the process of skinning. Skin the wings down to the wrist joints, detaching the roots of the larger feathers with the thumb or finger nails, removing the muscles from the bones but leaving the latter; or, make an incision on the under side along the bone, removing the flesh through the opening thus made. The latter method is preferable with large birds.

Skin the legs down to the lower joint of the thigh, remove the flesh from the bone, remove the muscle and fat, including the oil gland, from the base of the tail, but do not cut the roots of the feathers. To prevent stretching during the process of skinning, handle the skin as close as possible to the point of adhesion, a stretched skin being unsatisfactory in every respect; keep the feathers separate from the fleshy parts to prevent soiling the plumage and apply a suitable absorbent whenever a bloody or fatty surface is exposed.

Woodpeckers, ducks, etc., have the head so much larger than the neck that it is impossible to skin over it; in such cases cut the neck off before the skull is reached, turn the skin right side out, make an incision from the top of the head down to the base of the skull, and skin the head through the opening; stitch the incision together either before or after the specimen has been stuffed. Some birds have very tender skins that adhere to the rump or lower part of the back so closely that it is difficult to separate them; in such cases a little delay in skinning will facilitate the operation.

Birds having a white plumage very compact on the lower parts may be skinned through an incision along the side just under the wing, or on the back.

To poison the skin turn it wrongside out, lay it in the box containing the poison, and apply arsenic freely with brush, or other convenient method, taking care that it reaches every part of the head, particularly the base of the bill, about the wing, and leg bones and the base of the tail. After the poisoning is completed shake the skin over the box to detach loose powder.

The essential points in cleaning a bird skin are to never let the blood dry on the feathers; always use the absorbent immediately after washing, freeing it from the feathers before it dries.

To stuff a bird skin, fill the holes from which the eyeballs were removed with well rounded and elastic wads of cotton immediately after the skin is poisoned and while it is reversed; then form a roll of cotton around a knitting needle or other slender steel wire and insert it into the neck until the end can be grasped through the bill; withdraw the wire and push the end of the roll back from the mouth, so that when it is closed the cotton will not be exposed. If preferred, the end of the roll may be pushed into the skull cavity instead of the throat and the latter filled through the mouth; the latter method is preferable when the natural pose of the head is at a considerable angle with the neck. Next make up a soft oval wad or roll of cotton the size of the natural body, insert one end beneath the neck roll, which is raised and held up for the purpose, then work the wad into place by carefully pulling the skin over, taking a stitch or two to close the incision. The leg bones of large and medium-sized birds should be wrapped with cotton in order to fill out the thighs to their proper shape.

Birds with long necks or tender skins should have the stuffing wrapped around wires or sticks to strengthen them; if sticks are used the blunt anterior ends may be forced into the cavity of the skull; if wire is used it should be sharpened at both ends, one being forced through the anterior part of the head, the other through the root of the tail.

To shape or make up a specimen, lay it on its back on a thin sheet of raw cotton sufficiently large to inclose the skin when wrapped around it; fluff up the feathers under the wings, place the thumb and finger beneath them and gently press the sides together, as one would squeeze a wounded bird to kill it. When the body has thus been brought to its natural shape, bring the wings up against the sides in their normal position, allowing the side feathers to lay over them, and adjust the wing tips beneath the tail; lay the feet in a natural position, adjust the tail feathers and plumage wherever required, then roll carefully in the cotton in such a manner as to assist in retaining the contour previously given to the specimen. See that the bill is properly closed, either by a turn of a seizing, a stitch through the nostrils and around the lower mandible, or by twisting the cotton envelope around it. It is good practice to close the bill as soon as the neck has been stuffed.

The sex of a specimen should be determined by dissection, and when the generative organs have been destroyed by shot, or otherwise, omit the sex mark and substitute a query. If the organs are uninjured the sex may be readily ascertained, after the specimen is skinned, by making an incision in the side near the vertebræ and exposing the inner surface of the small of the back, where they will be found attached nearly on a line with the last ribs. The testicles of the male will be recognized as two

spheroidal or ellipsoidal whitish bodies, varying with the season and species from the size of a pin head to that of a hazelnut. The ovaries of the female, consisting of a flattened mass of spheres, variable in size with the season, will be found in the same region. A magnifying glass is useful in determining the sex of very small birds, particularly the young, in which the organs are but partially developed.

To prepare rough skeletons of birds, remove the skin and clean the bones, taking care to avoid injuring the delicate parts. The tools required are simply a knife and a pair of scissors.

The following points require special attention: Birds' wings terminate in very small, pointed bones, corresponding to the thumb of mammals, hidden in a tuft of feathers on the bend of the wing, which it is well to leave undisturbed, as well as the two or three outermost wing feathers, so as to avoid the risk of removing any of these small bones with the skin. Other parts requiring attention are the slender points on the under side of the neck vertebræ, those projecting backward from the ribs, and the last bone of the tail; if the tendons of the legs, wings, under side of the neck, and along the sides of the back, become ossified, as they sometimes do, it is not advisable to tear them off. In some birds the neck and back can be left untouched, as the muscles will dry up and a thin coat of arsenical soap will serve to keep out the insects which would otherwise attack these places. The hyoid bones, which support the tongue and are attached to the windpipe, should be saved, as also the windpipe itself whenever, as in many ducks, it has bony structures developed in part of its length.

In many birds, especially birds of prey, there is a ring of bones surrounding the pupil of the eye, hence it is safer not to remove the eyeball, but to simply puncture it to allow the escape of the fluid contents. The brain should be carefully removed.

Cormorants have a small bone attached to the back of the skull, and in auks and many similar birds there is a small bone at the elbow. Sometimes there is a little bone at the hinder angle of the lower jaw, so that it is a good rule not to trim a bird's skull too closely. A favorite method of collecting small birds for skeletonizing is to make an incision in the lower part of the abdomen and place them in 30 per cent alcohol.

NOTES ON SKINNING AND PRESERVING SKINS OF MAMMALS.

To skin small mammals a median line incision from the lower neck to the tail, through which the body is removed, is sufficient, while for large ones branch incisions along the inner surfaces of the legs to the feet are usually necessary. Leg bones are detached close to the body, and the skull separated from the neck, the tail bones are removed, the leg bones thoroughly cleaned of flesh, and the eyes and brain removed from the skull.

The brain is best removed through the large foramen, with a wire hook. In skinning the head care is taken not to injure the lips and eyelids, and the skull, after being cleaned, is kept separate from the skin. The skins of mammals of all sizes are thoroughly cleaned of flesh, and in small specimens the raw sides are dusted with arsenic, lightly filled with cotton, carefully shaped, and laid away to dry.

The skins of large mammals are disposed of on shipboard to the best advantage by salting thoroughly on the flesh side and rolling into a tight bundle and stowing in a barrel, with plenty of damp salt to cover it. If many such skins are to be cared for, they are placed as soon as cleaned in a barrel of very strong brine, which sets the hair on both sides, and keeps them pliable for the taxidermist who finally receives them.

The division of small mammals includes everything up to the size of the fox. Deer and bear skins are salted and air-dried. Thick-skinned animals, such as seals, are kept in damp salt or brine. All skins require prompt treatment in the tropics and should be examined occasionally in all climates.

PREPARATION OF ROUGH SKELETONS.

In the preparation of rough skeletons of mammals it is important to know the correct name of every animal and whenever it is unknown its skin should be taken off and kept as a means of identification. If an animal is shot, some of its bones are liable to be broken and such may be allowed to pass, but when it has been beaten to death, fracturing skull and limb bones generally, the animal had better be thrown away at once. If the skull alone is broken, select if possible another of the same size and send both with the body, and when convenient send with a broken leg another of the same size, but on no account throw away the fractured limb.

If an animal is rare, the skin should be carefully taken off and preserved; otherwise remove it roughly and disembowel the specimen, taking care not to cut into the breast-bone, especially the disk-shaped piece of cartilage in which it ends. Animals destined for skeletons should on no account be split up the breast as though they were being dressed for market.

Detach the legs from the body and remove the flesh, taking care in so doing not to remove the collar bone or kneepan with the meat. In the cat family the collar-bone is very small, and lies loose in the flesh, between the shoulder blade and front end of the breast-bone. The collar-bone of weasels is very minute and difficult to find, but climbing and burrowing animals usually have this bone well developed, uniting the shoulder-blade with the breast-bone. Deer, antelope, and seals have no collar-bone.

In small quadrupeds it will usually be unnecessary to detach the legs, but if convenience in roughing out or packing renders this desirable, cut the collar-bone loose from the breast-bone and leave it fastened to the shoulder-blade.

The legs being finished, disjoint and clean the skull. Be careful in removing the eyes not to thrust the point of the knife through the thin portion of the skull back of them, and in deer, antelope, or other ruminants take care not to break through the thin bone back of the upper teeth; also be careful not to cut off any projections of bone.

In cleaning the ribs, avoid cutting the cartilages joining them to the breast-bone, and, when the tail is reached, look out for a few little bones projecting downwards from the first few vertebræ. Fold the legs snugly along the body, or, if they have been detached, tie them together with the skull on the under side, as much as possible within the chest cavity; also turn down the tail and tie it upon itself. If there are any loose bones or splinters from a broken bone tie them up in a rag and fasten them to one of the long bones. Hang the skeleton up to dry, avoiding the hot sun or the heat of a fire if possible.

In the case of small skeletons that are likely to be some time in transit, it is desirable to give a thin coat of arsenical soap or other insect poison to preserve them from attack. The breast-bones of large animals should also be poisoned.

Embracing the upper part of the windpipe and connecting it with the base of the skull is a series of bones known as the hyoid apparatus, which should be carefully saved. There are usually small bones, termed sesamoids, imbedded in the tendons, where they play over the under sides of the toes, and on this account the tendons should never be cut off close to the bone.

There are often one or two small bones on the back lower portion of the thigh-bone; these should be left in place. In preparing the skeletons of rabbits, particular attention should be given to the shoulder-blade, as this has a slender projection at the lower end, which extends some distance backward.

The male organ of many quadrupeds, as the raccoon, is provided with a bone. As it is difficult to say when this may or may not be present, it should always be looked for, and when found left attached to the hip bones.

The *skeletons of porpoises, blackfish, etc.*, are very easily prepared, but one or two points, such as the slender cheek-bones and the pelvic-bones, or rudimentary hind limbs, require special care. The pelvic-bones are so small and so deeply imbedded in the flesh that they are too often thrown away. It frequently happens that the last rib lies loose in the flesh, with its upper end several inches from the back-bone. This should always be looked for. There are no bones in the sides of the tail or flukes nor in the back fin, and they can be cut off close to the body and thrown away. The hyoid is largely developed in most cetaceans, and will be found firmly attached to the base of the skull.

The tools required for making rough skeletons are a knife, scissors, and a few steel scrapers.

To rough out a turtle it is usually necessary to remove the under shell, although some species may be roughed out without detaching it. In sea turtles and a few others the plastron can be cut loose by taking a little time to the operation, but in the more solidly built tortoises and most fresh-water turtles it is necessary to saw through the bone. The interior of the body being exposed, it is a comparatively easy matter to cut away the flesh. Usually this can be done without disjointing any of the legs, and it is better, especially in small specimens, to have them attached to the body. Do not cut into any bones, as they are frequently soft and easily damaged.

Snakes require very little care in their preparation after the skin has been removed, but in the larger serpents rudimentary hind legs are present and should be carefully preserved. Externally the legs appear as two little claws situated on either side of the vent; internally they are slender bones, about an inch and a half in length, loosely attached to the ribs.

Do not try to skin through the mouth, but make a long cut on the under side and skin either way from it.

Fishes vary so much in structure that definite instructions for preparing their skeletons can not be given, yet a few general remarks may be of service. Most species have two rows of ribs. Use the knife slowly and carefully, as the edge will often give notice of an unsuspected bone, especially about the head, where there is a chain of bones encircling the eye, and the eyeball itself is often a bony cup.

Occasionally there are two or three bones attached to the back part of the head, and a patch of flesh on the cheek is about all that can safely be removed. When the skeleton is hung up to dry, place bits of wood between the gills to allow free circulation of air.

Ordinarily it is better for the collector to preserve fishes in alcohol and not attempt to prepare skeletons. The same may be said regarding most small mammals, reptiles, and birds.

The naturalists of the *Albatross* found useful auxiliaries for the preparation of certain classes of small skeletons in the amphipod crustaceans commonly called

"sea fleas," found in the shoal waters of nearly every sea and particularly abundant in Alaska. The specimen was first prepared by removing the skin and loose flesh, then tied in a small net and lowered over the ship's side, where it was allowed to hang just clear of the bottom. It would be discovered immediately and myriads of active little helpers would go to work, a few hours' time being all they required to clean the bones of every particle of flesh. They would eat bones and all if sufficient time was allowed them, but they like the soft parts best, and a little watchfulness on the part of the collector will insure a successful roughing out without injury to the skeleton.

In packing be sure that the skeleton is dry, particularly if it is a small one. In the case of a larger one it does not matter so much.

If it is the size of a deer, it should be disjointed, severing the back-bone just behind the ribs, in order to make a compact bundle. In larger specimens the back-bone may be cut into several sections, and the leg-bones separated at each joint. In the event of still smaller packages being required, the breast-bone may be separated from the ribs by cutting through the cartilage just below the end of each rib, when the latter may be detached from the back-bone, and thus dismantled a good-sized skeleton can be packed in a small box or barrel.

Straw, hay, or excelsior is the best packing material. Kelp, gulf weed, and all salt marsh or sea grasses should be avoided. In case of large skeletons salt may be sprinkled on the bones when it is impracticable to dry them, and the skeletons of seals, porpoises, etc., may be packed in salt.

The tag or label should be no larger than required; it should be sufficiently strong to withstand frequent handling, and a metal eyelet at one end will add much to its security. It should be legibly marked with the following data: The number, definite locality, date, year, month, and day; sex, using the ordinary signs ♂ for male and ♀ for female, and name of the collector. Other information is better given in the field book. The label should be tied with a square knot, to one leg, and the ends cut to not more than an inch in length; cotton sail-twine makes a safe and convenient seizing. Skins require drying before they are packed for shipment or placed in a storeroom, unless the latter is sufficiently warm and dry; it is not good practice to dry by artificial heat. Skins are liable to be attacked by insects about the bill, feet, shafts of wing, and tail feathers, etc., and any good insect poison may be used as a preventive.

The *field notes* of a collector should be full and explicit, as they determine largely the value of the specimen. They should be written in a book, on one side of the page, and should include observations on the habits, etc., of the various species, the localities they frequent, their food, and generally their life-history. He should catalogue his specimens, beginning with No. 1, numbering them serially as taken, in order to avoid duplication, making sure also that the numbers on label and catalogue correspond.

BLANK FORMS OF RECORDS.

The following blank forms of records kept on board the *Albatross* will be found useful not only as a basis for making similar forms, but as reminders of the valuable information that can be given, in tabulated form, on board of seagoing vessels by the expenditure of very little time and labor. It will be observed that some of the data are repeated on two or more forms. This method admits of the subdivision of reports, all complete in themselves, and made out on sheets of ordinary and convenient size.

Blank forms from the United States Hydrographic Office, and from other branches of the United States Government, are not included, as they are furnished to vessels by the Department requiring special information.

All hydrographic or other information obtained by the *Albatross* that is useful for making or correcting charts, or sailing directions, is furnished to the United States Hydrographic Office and United States Coast and Geodetic Survey.

Blank pages of sounding and dredging record book.

No .... Date ....
.... Machine. ...... Reel. ....
Turns........ Cor. + ... Depth ....
Shot or lead ....
Bottom ....
Bottom temperature ....
No. of thermometer .... Cor. ....
Corrected temperature ....
Air.............. Surface .... Drift ....
Trawl or dredge ....

Sounding wire.		Turns.	Dredge rope.	
Down.	Up.		Down.	Up.
		0		
		100		
		200		
		300		
		400		
		500		
		600		
		700		
		800		
		900		
		1000		
		1100		
		1200		
		1300		
		1400		
		1500		
		1600		
		1700		
		1800		
		1900		
		2000		
		2100		
		2200		
		2300		
		2400		
		2500		
		2600		
		2700		
		2800		
		2900		
		3000		
		3100		
		3200		
		3300		
		3400		
		3500		
		3600		
		3700		
		3800		
		3900		
		4000		

SERIAL TEMPERATURES.

Depth.	Temp.	No. of ther.	Cor.	Cor. Temp.
25				
50				
100				
200				
300				
400				
500				
600				
700				
800				
900				
1000				

REMARKS.

Navigator's report—Summary of the movements of the Albatross for the year.

Date.	Movements.	Distance.	Object.
		Miles.	

The above table gives the number of days the vessel was at sea during the year; also the distance run and the object of each trip.

Record of hydrographic soundings.

Serial No.	Date.	Time of day.	Position.		Depth.	Character of bottom.	Temperature.			Instrument used.	Weight of sinker.
			Lat. N.	Long. W.			Air.	Surface.	Bottom.		
			° ′ ″	° ′ ″	*Fms.*		° F.	° F.	° F.		*Lbs.*

Record of temperatures and specific gravities.

Date.	Time of day.	Station.	Lat. N.	Long. W.	Depth.	Temperature of specimen when taken.	Temperature of air.	Temperature of specimen at time specific gravity was taken.	Specific gravity.	Specific gravity reduced to 15° C., with pure water at 4° C. as standard.
			° ′ ″	° ′ ″	*Fms.*	° F.	° F.	° C.		

Record of serial temperatures.

Date.	Serial No.	Position.		Depth (fathoms).	Character of bottom.	Temperature (degrees F.).															
		Lat. N.	Long. W.			Air.	Surface.	25 fathoms.	50 fathoms.	100 fathoms.	200 fathoms.	300 fathoms.	400 fathoms.	500 fathoms.	600 fathoms.	700 fathoms.	800 fathoms.	900 fathoms.	1,000 fathoms.	Bottom.
		° ′ ″	° ′ ″																	

Record of meteorological observations.

Date.	Position at meridian.		Barometer.		Temperature.						Weather.	Direction and force of winds.	Rainfall.
					Air: Dry bulb.		Air: Wet bulb.		Water at surface.				
	Lat. N.	Long. W.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.			
	° ′ ″	° ′ ″	°	°	°	°	°	°	°	°			

Meteorological and cruising record. North Pacific and Bering Sea.

Date.	Meridian position.		Distance run per log.	Barometer.		Temperature.						State of the weather.	Force and direction of winds.	Rainfall (approx).	State of sea.	Currents.	Strength in knots per hour.	Number of hours sealing weather.	Number of seals seen.
						Air.				Water at surface.									
						Dry bulb.		Wet bulb.											
	Lat. N.	Long. W.		Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.								
	° ′ ″	° ″ ′	Knots.																

Record of Tanner intermediate tow-net stations.

Serial No.	Date.	Time.	Position.		Temperatures.			Depth.	Wind.		Drift.		Mean depth.	Remarks.
			Lat. N.	Long. W.	Air.	Surface.	Bottom.		Direction.	Force.	Towed at a depth.	Time towing.		
			° ′ ″	° ′ ″				*Fath.*			*Fath.*	*Min.*	*Fath.*	

Record of dredging and trawling stations.

ABBREVIATIONS USED IN THIS TABLE: m., mud; s., sand; g., gravel; co., coral; sh., shells; p., pebbles; sp., specks; c., clay; st., stones; r., rock, bk., black; wh., white; yl., yellow; gy., gray, bu., blue; dk., dark; lt., light; gn., green; br., brown; hrd., hard; sft., soft; fne., fine; crs., coarse; brk., broken; lrg., large; sml., small, rky., rocky; stk., sticky, oz., ooze; for., foraminifera; glob., globigerina. L. B. T., large beam-trawl, S. B. T., small beam-trawl; Tgl. bar, tangle-bar, Bl. dr., Blake dredge Sh dr., Ship's dredge.

Serial No.	Date	Time	Position		Temperatures			Depth	Character of bottom.	Wind		Drift (mag.)		Instrument used
			Lat N	Long W	Air.	Surface	Bottom			Direction	Force.	Direction	Distance	
			° ′ ″	° ′ ″	°F.	°F.	°F.	*Fathoms.*					*Miles*	

Record of trial line fishing for cod

Date	Serial No	Position		Depth	Nature of bottom.	Length of trial.	No. of lines used	No of cod taken	Range in weight	Average weight.	Range in length.	Average length	Bait used.
		Lat. N.	Long W.										
		° ″	° ′ ″	*Fathoms.*		*Min*			*Pounds*	*Pounds*	*Inches*	*Inches*	

Record of fishing stations.

Date	Serial No	Position.		Depth.	Character of bottom.	Bottom temp.	Instrument used	Length of time	Food fishes taken.
		Lat. N.	Long W.						
		° ′ ′	° ′′	*Fathoms*				*hrs. m*	

Record of fishing stations, Atlantic and Gulf Coasts.

Date.	Time.	Position. Lat. N	Position. Long. W.	Depth (fathoms)	Character of bottom.	Temperature. Air.	Temperature. Surface.	Temperature. Bottom.	Object of search.	Implement used.	Tilefish (*Lopholatilus chamæleonticeps*).	Hake (*Phycis tenuis*)	Whiting (*Merluccius bilinearis*).	Skate (*Raia* sp.)	Dogfish (*Mustelus canis*).	Codfish (*Gadus morrhua*).	Red grouper (*Epinephelus morio*)	Black bass (*Centropristes striatus*)	Red snapper (*Neomænis aya*)	Black grouper (*Garrupa nigrita*).	Haddock (*Melanogrammus æglifinus*).	Norway haddock (*Sebastes marinus*).	Miscellaneous.
		° ′ ″	° ′ ″			°	°	°	General.	Hand-line.													

Record of animal life, driftwood, kelp, etc., observed from deck of Albatross at sea.

FROM PORT TOWNSEND, WASH., FOR UNALASKA, ALASKA.

Date.	Meridian position. Lat N.	Meridian position. Long. W.	Mean temperature. Air. Dry bulb.	Mean temperature. Water. Surface.	Fur-seals.	Whales	Auks.	Cormorants.	Ducks.	Gulls.	Goneys.	Guillemots.	Petrels.	Puffins.	Terns.	Drift-wood.	Kelp	Remarks

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